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BIOSYSTEMATIC CONTRIBUTIONS TO AGROMYZIDAE (DIPTERA)

RICARDO GIL ORTIZ

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Biosystematic contributions to Agromyzidae (Diptera)

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Ricardo Gil Ortiz

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Vº Bº del director

Dr. Ricardo Jiménez Peydró

Vº Bº del tutor

Dr. Fernando García Marí

A mis padres

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Note: This doctoral thesis has been organized so that the main results have been written in the form of scientific articles published in international Journals, or in process of being published. The chapters of this thesis that correspond to the wording on the basis of scientific articles are 5.4 (New reports for Agromyzidae), 5.5 (New species for science), 6.3 (New host-plants for Agromyzidae (Diptera) from Eastern Spain), 6.4 (*Liriomyza*-wild-plant interactions (Diptera: Agromyzidae) in mediterranean ecosystems) and 6.5 (Modelling climate effects on the ecological dynamics of *Pseudonapomyza* (Diptera: Agromyzidae) genus).

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Abstract

The Agromyzidae family includes the most important dipterous species miners of crops for agriculture. Knowledge of 2900 worldwide species are cited, of which about 7% are considered of agronomic interest. Despite the high specificity that has Agromyzidae by their host-plants, it is noted that in recent decades there has been a significant increase of the oligophagy and polyphagy of many species due to the constant change produced in the ecosystems and the increase of the number of intensive crops.

Knowledge of the Agromyzidae biodiversity is one of the main factors to be considered under the control of present and future pests. As result of a systematic biodiversity study in the three parks of Eastern Spain: "Tinença de Benifassà" (Castellón), "Font Roja" (Alicante) and "Lagunas de La Mata-Torrevieja" (Alicante) new faunistic data included in 6 Agromyzidae genera are presented. Thirteen new species collected with Malaise trap are recorded for the first time in Spain: *Agromyza anthracina* Meigen, 1830; *A. bromi* Spencer, 1966; *A. hiemalis* Becker, 1908; *A. megalopsis* Hering, 1933; *Aulagromyza luteoscutellata* (de Meijere, 1924); *Au. similis* (Brischke, 1880); *Au. trivitatta* (Loew, 1873); *Liriomyza graminivora* Hering, 1949; *Melanagromyza eupatorii* Spencer, 1957; *M. spinulosa* Spencer, 1974; *Phytobia cerasiferae* (Kangas, 1955); *Ph. lunulata* (Hendel, 1920) and *Pseudonapomyza palliditarsis* Cerny, 1992. General information about the host-plants and geographical distribution are included.

A new Agromyzidae pest is reported in Spain, *Melanagromyza sojae* (Zehnter, 1900). The stem-miner was captured with Malaise trap in "Tinença de Benifassà". Information is given about distribution, damage, control, host-plants, biology and ecology of this pest. Identification rules are indicated by its distinction from the rest of Agromyzidae miners on soybean in Europe.

Pseudonapomyza atratula Zlobin, 2002 a species earlier known only in Tunisia is reported for the first time in Europe (Spain). Their host-plants, *Avena barbata* Pott ex Link and *A. fatua* L. are indicated here for the first time. *Ps. atratula* belongs to the same group of species as *Ps. atra* (Meigen, 1830). Morphological criteria are given to separate these two closely connected species, in particular on the genitalia of the males. Some biological and phenological elements are also given for *Ps. atratula.*

Five new species for *Pseudonapomyza* are described: *Ps. curvata* n. sp; *Ps. benifassae* n. sp.; *Ps. longitata* n. sp.; *Ps. mediterranea* n. sp. and *Ps. sicicornis* n. sp. In addition, nineteen new species for science belonging to *Agromyza*, *Cerodontha*, *Liriomyza*, *Metopomyza*, *Ophiomyia* and *Phytomyza* genera are reported to be considered into Agromyzidae fauna.

A tool for the ecological studies of habitats is their biodiversity analysis. The biodiversity alpha (α), beta (β) and gamma (γ) for each one of the Natural Parks are studied with both, biodiversity indexes and captures approximation to different statistical models.

This study presents 34 new host-plants for Agromyzidae from a total of 153 interactions established in 94 genera belonging to 27 botanical families. The interactions were established in three Natural Parks from Eastern Spain on 27 Agromyzidae species: *Ophiomyia beckeri* (Hendel, 1923); *O. ononidis* Spencer, 1966; *Amauromyza (Amauromyza) balcanica* (Hendel, 1931); *A. (Amauromyza) carlinae* (Hering, 1944); *A. (Amauromyza) morionella* (Zetterstedt, 1848); *A. (Cephalomyza) flavifrons* (Meigen, 1830); *A. (Cephalomyza) karli* (Hendel, 1927); *Chromatomyia horticola* (Goureau, 1851); *Chr. periclymeni* (Hendel, 1922); *Liriomyza brassicae* (Riley, 1884); *L. bryoniae* (Kaltenbach, 1858); *L. cicerina* (Rondani, 1875); *L. congesta* (Becker, 1903); *L. dianthicola* (Venturi, 1949); *L. orbona* (Meigen, 1830); *L. pascuum* (Meigen, 1838); *L. strigata* (Meigen, 1830); *L. trifolii* (Burgess in Comstock, 1880); *Napomyza lateralis* (Fallén, 1823); *Phytomyza hellebori* Kaltenbach, 1872; *P. plantaginis* Robineau-Desvoidy, 1851; *Pseudonapomyza atratula* Zlobin, 2002; and five species belonging to *Liriomyza*, *Phytomyza* and *Pseudonapomyza* genera. Agromyzidae damages on families and botanical genera are studied and broken down in function of botanical species and their miners.

Pseudonapomyza is one of the leaf-miners genera of monocots in the southeast area of Spain. Knowledge of the population fluctuation of these Agromyzidae miners is key to the establishment of control measures. It shows the close relationship between fluctuating temperatures and the miners evolution through the use of multivariate statistical tools. *Pseudonapomyza* captures were studied throughout three years of sampling with Malaise trap. It is noted that 82% of the differences in captures are due to the *Pseudonapomyza* bioecology within each park, being essentially the temperature the factor that explains the 79% of the population dynamics in the areas studied.

Key Words: Diptera, Agromyzidae, biodiversity, new report, new species for science, new interaction, host-plants, ecology, phenology, climate, population dynamics, Spain, Europe.

Résumé

Par ses larves mineuses de feuilles, de tiges, de cambium, de racines, de graines ou de têtes florales la famille des Agromyzidae est, avec celle des Tephritidae, l'une des plus importantes pour l'agriculture par les dégâts qu'elle occasionne. On connaît environ 2900 espèces de Diptères Agromyzidae, dont environ 7% sont d'intérêt agronomique. Malgré l'étroite spécificité des Agromyzidae à leurs plantes hôtes, on observe depuis quelques décennies une augmentation significative de l'oligophagie et de la polyphagie de nombreuses espèces, cette augmentation est probablement liée à l'évolution des écosystèmes cultivés (culture intensive, réduction de la faune auxiliaire...).

La connaissance de la biodiversité des Agromyzidae est l'un des principaux facteurs à considérer dans le cadre d'une gestion durable des ravageurs d'intérêts agronomiques, présentes et futurs. À la suite de l'étude menée dans trois réserves naturelles de l'est de l'Espagne: “Tinença de Benifassà” (Castellon), “Font Roja” (Alicante) et “Lagunas de La Mata-Torrevieja” (Alicante) de nouvelles données faunistiques, écologiques et systématiques ont été acquises; elles concernent 6 genres d'Agromyzidae. 13 espèces nouvelles pour l'Espagne ont été capturées à l'aide de pièges Malaise: *Agromyza anthracina* Meigen, 1830; *A. bromi* Spencer, 1966; *A. hiemalis* Becker, 1908; *A. megalopsis* Hering, 1933; *Aulagromyza luteoscutellata* (de Meijere, 1924); *Au. similis* (Brischke, 1880); *Au. trivitatta* (Loew, 1873); *Liriomyza graminivora* Hering, 1949; *Melanagromyza eupatorii* Spencer, 1957; *M. spinulosa* Spencer, 1974; *Phytobia cerasiferae* (Kangas, 1955); *Ph. lunulata* (Hendel, 1920) et *Pseudonapomyza palliditarsis* Cerny, 1992. Les plantes hôtes et la répartition géographique de ces espèces sont indiquées de façon exhaustive d'après nos propres données et celle de la littérature.

L'espèce *Melanagromyza sojae* (Zehnter, 1900), ravageur de grande importance économique, particulièrement sur haricot et soja, est citée pour la première fois d'Europe comme organisme nuisible. Ce Diptère mineur de tige a été capturé dans un piège Malaise dans le parc naturel de “Tinença de Benifassà”. Des informations sur sa distribution, ses plantes hôtes, sa biologie, son écologie, ses dégâts et son contrôle, sont données; de même que des éléments permettant de distinguer cette espèce d'autres vivant sur les mêmes espèces hôtes de Leguminosae (Fabaceae).

Pseudonapomyza atratula Zlobin, 2002, connue jusqu'à présent seulement de Tunisie, est citée pour la première fois en Europe. Ses plantes-hôte jusqu'alors inconnues sont *Avena barbata* Pott ex Link et *A. fatua* L. *P. atratula* est apparentée à *P. atra* (Meigen, 1830) les 2 espèces appartenant au même groupe. Les critères pour la distinction de ces deux espèces proches sont décrites, en particulier la structure morphologique des genitalia mâles. Des éléments inédits relatifs à la biologie et la phénologie de *Ps. atratula* sont rapportés.

Cinq espèces nouvelles pour la science sont décrites elles appartiennent toutes au genre *Pseudonapomyza,* il s'agit de: *Ps. curvata* n. sp; *Ps. benifassae* n. sp.; *Ps. longitata* n. sp.; *Ps. mediterranea* n. sp. et *Ps. sicicornis* n. sp. Au cours de mes recherches 19 autres espèces nouvelles pour la science appartenant aux genres

Agromyza, *Cerodontha*, *Liriomyza*, *Metopomyza*, *Ophiomyia* et *Phytomyza* ont été collectés, celles ci ne sont pas décrites ici mais font l'objet d'un bref commentaire.

Un outil pour l'étude de l'écologie des habitats et l'analyse de leurs biodiversité a été testé et validé. A l'aide des indices de la diversité biologique, du rapprochement des captures dans les différents modèles statistiques il a pu être étudié la biodiversité (α), bêta (β) et gamma (γ) pour chacun des parcs échantillonnées.

Au cours de mes recherches 34 nouvelles associations trophiques (Agromyzidae plantes hôtes) ont été trouvées pour un total de 153 interactions établies dans 94 genres appartenant à 27 familles botaniques. Elles proviennent de trois réserves naturelles à l'est de l'Espagne et concernent 27 espèces d'Agromyzidae: *Ophiomyia beckeri* (Hendel, 1923); *O. ononidis* Spencer, 1966; *Amauromyza (Amauromyza) balcanica* (Hendel, 1931); *A. (Amauromyza) carlinae* (Hering, 1944); *A. (Amauromyza) morionella* (Zetterstedt, 1848); *A. (Cephalomyza) flavifrons* (Meigen, 1830); *A. (Cephalomyza) karli* (Hendel, 1927); *Chromatomyia horticola* (Goureau, 1851); *Chr. periclymeni* (Hendel, 1922); *Liriomyza brassicae* (Riley, 1884); *L. bryoniae* (Kaltenbach, 1858); *L. cicerina* (Rondani, 1875); *L. congesta* (Becker, 1903); *L. dianthicola* (Venturi, 1949); *L. orbona* (Meigen, 1830); *L. pascuum* (Meigen, 1838); *L. strigata* (Meigen, 1830); *L. trifolii* (Burgess in Comstock, 1880); *Napomyza lateralis* (Fallén, 1823); *Phytomyza hellebori* Kaltenbach, 1872; *P. plantaginis* Robineau-Desvoidy, 1851; *Pseudonapomyza atratula* Zlobin, 2002; et cinq espèces appartenant au genres *Liriomyza*, *Phytomyza* et *Pseudonapomyza*.

Le genre *Pseudonapomyza* est l'un des plus importants genres de diptères mineurs de plantes monocotylédones dans le sud d'Espagne. La connaissance de la fluctuation de ces mineurs Agromyzidae est la clé pour la prise en compte de décision et la réussite de mesures de contrôle. Il est montré la relation étroite entre les fluctuations de températures et l'évolution de ces diptères en utilisant les outils statistiques multivariées. Les captures de *Pseudonapomyza* ont été étudiés au cours de 3 années de piégeages avec des tentes Malaise. Il est souligné que 82% des différences notés dans les captures, dans les parcs étudiés, sont dues à la bioécologie des *Pseudonapomyza* à l'intérieur de chaque parc. La température est le facteur essentiel qui explique 79% de la dynamique des populations dans les zones étudiées.

Mots-clés: Diptera, Agromyzidae, biodiversité, nouvelles citations, nouvelles espèces, nouvelles interactions trophiques, plantes hôtes, écologie, phénologie, climat, dynamique de populations, Espagne, Europe.

Resumen

La familia Agromyzidae incluye las especies de dípteros minadores más importantes para la Agricultura. Se conocen 2900 especies en el mundo de las cuales cerca del 7% se consideran de interes agronómico. A pesar de la alta especificidad de Agromyzidae por sus plantas hospedadoras, se ha observado en las últimas décadas un incremento significativo de la oligofagia y polifagia de muchas especies asociado al cambio constante producido en los ecosistemas y al incremento del cultivo intensivo.

El conocimiento de la biodiversidad de Agromyzidae es uno de los principales factores a tener en cuenta en el control de plagas presentes y futuras. Como resultado del estudio sistemático realizado en tres parques naturales de la España oriental: "Tinença de Benifassà" (Castellón), "Font Roja" (Alicante) y "Lagunas de La Mata-Torrevieja" (Alicante) se presentan nuevos datos faunísticos incluidos en 6 géneros de Agromyzidae. Se citan por primera vez 13 nuevas especies capturadas con trampa Malaise en España: *Agromyza anthracina* Meigen, 1830; *A. bromi* Spencer, 1966; *A. hiemalis* Becker, 1908; *A. megalopsis* Hering, 1933; *Aulagromyza luteoscutellata* (de Meijere, 1924); *Au. similis* (Brischke, 1880); *Au. trivitatta* (Loew, 1873); *Liriomyza graminivora* Hering, 1949; *Melanagromyza eupatorii* Spencer, 1957; *M. spinulosa* Spencer, 1974; *Phytobia cerasiferae* (Kangas, 1955); *Ph. lunulata* (Hendel, 1920); y *Pseudonapomyza palliditarsis* Cerny, 1992. Se incluye información general de las plantas hospedadoras y su distribución geográfica.

Se cita una nueva plaga dentro de la familia Agromyzidae, *Melanagromyza sojae* (Zehnter, 1900). Este minador de tallos fue capturado con trampa Malaise en el Parque Natural de la "Tinença de Benifassà". Se incluye información de la distribución, daño, control, plantas hospedadoras, biología y ecología de esta plaga. A su vez, se indican criterios de identificación para su distinción del resto de minadores de Agromyzidae sobre la soja en Europa.

Se cita la presencia de *Pseudonapomyza atratula* Zlobin, 2002 por primera vez en Europa, una especie de reciente descripción en Tunisia. Se citan por primera vez sus plantas hospedadoras, *Avena barbata* Pott ex Link and *A. fatua* L. *Ps. atratula* pertenece al mismo grupo que *P. atra* (Meigen, 1830). Se aportan criterios para la distinción de estas dos especies próximas, en particular mediante la estructura morfológica del macho. Se señalan también aspectos de la biología y fenología de *Ps. atratula*.

Se incluye la descripción de 5 nuevas especies pertenecientes al género *Pseudonapomyza*: *Ps. curvata* n. sp; *Ps. benifassae* n. sp.; *Ps. longitata* n. sp.; *Ps. mediterranea* n. sp. and *Ps. sicicornis* n. sp. Además, se indica la presencia de 19 nuevas especies para la ciencia, dentro de la familia Agromyzidae, pertenecientes a los géneros *Agromyza*, *Cerodontha*, *Liriomyza*, *Metopomyza*, *Ophiomyia* y *Phytomyza.*

Una herramienta para el estudio ecológico de los hábitats es el análisis de su biodiversidad. Se estudia la biodiversidad (α), beta (β) y gamma (γ) para cada uno de

los parques naturales estudiados mediante el cálculo de indices de biodiversidad y la aproximación de las capturas a diferentes modelos estadísticos.

Este estudio presenta 34 nuevas plantas hospedadoras para Agromyzidae de un total de 153 interacciones establecidas en 94 géneros pertenecientes a 27 familias botánicas. Las interacciones fueron establecidas en tres parques naturales de la zona Este de España sobre 27 especies incluidas en la familia Agromyzidae: *Ophiomyia beckeri* (Hendel, 1923); *O. ononidis* Spencer, 1966; *Amauromyza (Amauromyza) balcanica* (Hendel, 1931); *A. (Amauromyza) carlinae* (Hering, 1944); *A. (Amauromyza) morionella* (Zetterstedt, 1848); *A. (Cephalomyza) flavifrons* (Meigen, 1830); *A. (Cephalomyza) karli* (Hendel, 1927); *Chromatomyia horticola* (Goureau, 1851); *Chr. periclymeni* (Hendel, 1922); *Liriomyza brassicae* (Riley, 1884); *L. bryoniae* (Kaltenbach, 1858); *L. cicerina* (Rondani, 1875); *L. congesta* (Becker, 1903); *L. dianthicola* (Venturi, 1949); *L. orbona* (Meigen, 1830); *L. pascuum* (Meigen, 1838); *L. strigata* (Meigen, 1830); *L. trifolii* (Burgess in Comstock, 1880); *Napomyza lateralis* (Fallén, 1823); *Phytomyza hellebori* Kaltenbach, 1872; *P. plantaginis* Robineau-Desvoidy, 1851; *Pseudonapomyza atratula* Zlobin, 2002; y cinco especies pertenecientes a los géneros *Liriomyza*, *Phytomyza* y *Pseudonapomyza*.

Pseudonapomyza es uno de los géneros de dípteros minadores de plantas monocotiledóneas del Sudeste de España. El conocimiento de la fluctuación de estos minadores Agromyzidae es clave para el establecimiento de medidas de control. Se muestra la estrecha relación existente entre la fluctuación de las temperaturas y la evolución de estos dípteros mediante el uso de herramientas estadísticas multivariantes. Las capturas de *Pseudonapomyza* fueron estudiadas durante 3 años de capturas con trampa Malaise. Destaca que el 82% de las diferencias de las capturas observadas entre los parques naturales estudiados se deben a la bioecología de *Pseudonapomyza* dentro de cada Parque Natural, siendo esencialmente la temperatura el factor que explica el 79% de la dinámica poblacional en las áreas estudiadas.

Palabras clave: Diptera, Agromyzidae, biodiversidad, nueva cita, nueva especie para la ciencia, nueva interacción, plantas hospedadoras, ecología, fenología, clima, dinámica poblacional, España, Europa.

Resum

La família Agromyzidae inclou les espècies de dípters minadors més importants per a l'Agricultura. Es coneixen 2.900 espècies en el món de les quals prop del 7% es consideren d'interès agronòmic. Malgrat l'alta especificitat de Agromyzidae per les seves plantes hospedadores, s'ha observat en les últimes dècades un increment significatiu de la oligofagia i polifàgia de moltes espècies associat al canvi constant produït en els ecosistemes i l'increment del cultiu intensiu.

El coneixement de la biodiversitat d'Agromyzidae és un dels principals factors a tenir en compte en el control de plagues presents i futures. Com a resultat de l'estudi sistemàtic realitzat en tres parcs naturals de l'Espanya oriental: "Tinença de Benifassà" (Castelló), "Font Roja" (Alacant) i "Lagunas de La Mata-Torrevieja" (Alacant) es presenten noves dades faunístiques incloses en 6 gèneres Agromyzidae. Es citen per primera vegada 13 noves espècies capturades amb trampa Malaise a Espanya: *Agromyza anthracina* Meigen, 1830; *A. bromi* Spencer, 1966; *A. hiemalis* Becker, 1908; *A. megalopsis* Hering, 1933; *Aulagromyza luteoscutellata* (de Meijere, 1924); *Au. similis* (Brischke, 1880); *Au. trivitatta* (Loew, 1873); *Liriomyza graminivora* Hering, 1949; *Melanagromyza eupatorii* Spencer, 1957; *M. spinulosa* Spencer, 1974; *Phytobia cerasiferae* (Kangas, 1955); *Ph. lunulata* (Hendel, 1920) i *Pseudonapomyza palliditarsis* Cerny, 1992. S'hi inclou informació general de les plantes hospedadores i de la seva distribució geogràfica.

Se cita una nova plaga dins de la família Agromyzidae, *Melanagromyza sojae* (Zehnter, 1900). Aquest minador de tiges va ser capturat amb trampa Malaise al Parc Natural de "Tinença de Benifassà". S'inclou informació de la distribució, dany, control, plantes hospedadores, biologia i ecologia d'aquesta plaga. Al seu torn, s'indiquen criteris d'identificació per a la seva distinció de la resta de minadors d'Agromyzidae sobre la soja a Europa.

Se cita la presència de *Pseudonapomyza atratula* Zlobin, 2002 per primera vegada a Europa, una espècie de recent coneixement en Tunisia. S'indiquen per primera vegada les seves plantes hospedadores, *Avena barbata* Pott ex Link and *A. fatua* L. *Ps. atratula* pertany al mateix grup que *Ps. atra* (Meigen, 1830). S'aporten criteris per a la distinció d'aquestes dues espècies pròximes, en particular mitjançant l'estructura morfològica de la genitalia del mascle. S'assenyalen també aspectes de la biologia i fenologia de *Ps. atratula*.

S'inclou la descripció de 5 noves espècies pertanyents al gènere *Pseudonapomyza*: *Ps. curvata* n. sp; *Ps. benifassae* n. sp.; *Ps. longitata* n. sp.; *Ps. mediterranea* n. sp. i *Ps. sicicornis* n. sp. A més, s'indica la presència de 19 noves espècies per a la ciència dins d'Agromyzidae pertanyents als gèneres *Agromyza*, *Cerodontha*, *Liriomyza*, *Metopomyza*, *Ophiomyia* i *Phytomyza*.

Una eina per a l'estudi ecològic dels hàbitats és l'anàlisi de la seva biodiversitat. S'estudia la biodiversitat (α), beta (β) i gamma (γ) per a cadascun dels parcs naturals

estudiats mitjançant indices de biodiversitat i l'aproximació de les captures a diferents models estadístics.

Aquest estudi presenta 34 noves plantes hospedadores per Agromyzidae d'un total de 153 interaccions establertes en 94 gèneres pertanyents a 27 famílies botàniques. Les interaccions van ser establertes en tres parcs naturals de la zona est d'Espanya sobre 27 espècies dins d'Agromyzidae: *Ophiomyia beckeri* (Hendel, 1923); *O. ononidis* Spencer, 1966; *Amauromyza (Amauromyza) balcanica* (Hendel, 1931); *A. (Amauromyza) carlinae* (Hering, 1944); *A. (Amauromyza) morionella* (Zetterstedt, 1848); *A. (Cephalomyza) flavifrons* (Meigen, 1830); *A. (Cephalomyza) karli* (Hendel, 1927); *Chromatomyia horticola* (Goureau, 1851); *Chr. periclymeni* (Hendel, 1922); *Liriomyza brassicae* (Riley, 1884); *L. bryoniae* (Kaltenbach, 1858); *L. cicerina* (Rondani, 1875); *L. congesta* (Becker, 1903); *L. dianthicola* (Venturi, 1949); *L. orbona* (Meigen, 1830); *L. pascuum* (Meigen, 1838); *L. strigata* (Meigen, 1830); *L. trifolii* (Burgess in Comstock, 1880); *Napomyza lateralis* (Fallén, 1823); *Phytomyza hellebori* Kaltenbach, 1872; *P. plantaginis* Robineau-Desvoidy, 1851; *Pseudonapomyza atratula* Zlobin, 2002; i cinc espècies pertanyents als gèneres *Liriomyza*, *Phytomyza* i *Pseudonapomyza*.

Pseudonapomyza és un dels gèneres de dípters minadors de plantes monocotiledònies del Sud-est d'Espanya. El coneixement de la fluctuació d'aquests minadors Agromyzidae és clau per a l'establiment de mesures de control. Es mostra l'estreta relació entre la fluctuació de les temperatures i l'evolució d'aquests dípters mitjançant l'ús d'eines estadístiques multivariants. Les captures de *Pseudonapomyza* van ser estudiades durant 3 anys de captures amb trampa Malaise. Destaca que el 82% de les diferències de les captures observades entre els parcs naturals estudiats es deuen a la bioecología de *Pseudonapomyza* dins de cada Parc Natural, essent essencialment la temperatura el factor que explica el 79% de la dinàmica poblacional en les àrees estudiades.

Paraules clau: Diptera, Agromyzidae, biodiversitat, nova cita, nova espècie per a la ciència, nova interacció, plantes hospedadores, ecologia, fenologia, clima, dinàmica poblacional, Espanya, Europa.

Papers & Communications

PART I. SYSTEMATICS

Papers

1. New additions to the biodiversity of Agromyzidae (Diptera) from Spain (Accepted date 25/07/09 in the *Journal of Entomological Science*).
2. New contributions to *Pseudonapomyza* (Diptera: Agromyzidae) from Spain: addition of three new species (Submitted to *Journal of Insect Science*).
3. *Pseudonapomya mediterranea* n. sp. (Diptera: Agromyzidae) from salt marshes in Spain (Accepted date 29/07/09 in *Entomological News*).
4. Additions to *Pseudonapomyza* (Diptera: Agromyzidae) genus from Spain (Accepted date 15/07/09 in *Entomologica Fennica*).
5. *Pseudonapomyza atratula* Zlobin, 2002 (Diptera: Agromyzidae), new species for the European continent (Accepted date 22/07/09 in the *Journal of Entomological Science*).

Notes

6. First record of *Melanagromyza sojae* (Zehnter, 1900) (Diptera: Agromyzidae) in Europe (Accepted date 24/07/09 in the *Journal of Entomological Science*).

PART II. ECOLOGICAL ASPECTS

Papers

7. New host-plants for Agromyzidae (Diptera) from Eastern Spain. (Published in *Bollettino di Zoologia agraria e di Bachicoltura*, Ser. II, 42 (2): 43-58, 2009).
8. *Liriomyza* wild-plant interactions (Diptera: Agromyzidae) in Mediterranean ecosystems (Published in *Communications in Agricultural and Applied Biological Sciences*, Ghent University, 73 (3): 573-582, 2008).
9. Modelling climate effects on the ecological dynamics of *Pseudonapomyza* (Diptera: Agromyzidae) genus (Submitted to *Ecological Entomology*).

COMMUNICATIONS

10. Interacciones entre Agromyzidae (Diptera) de Ecosistemas Mediterráneos y sus plantas hospedadoras (Oral Communication - *XIII Congreso Ibérico de Entomología* - EIA. 8-12 Sept. 2008, Seia, Portugal).
11. Evolución espacio-temporal de Agromyzidae asociada a capturas con trampa malaise en la comunidad valenciana (Poster Communication - *XIII Congres Ibérico de Entomología* – EIA, 8-12 Sept. 2008, Seia, Portugal).
12. Plant-Insect Interactions in Mediterranean Ecosystems of Spain (Diptera: Agromyzidae) (Poster Communication - *60th International Symposium on Crop Protection*, 20 May 2008, Gent, Belgium).

13. La technique du barcoding de l'ADN: un outil pour l'identification et la systématique des Agromyzidae (Diptera) (Oral Communication - *8ème Conférence Internationale sur les Ravageurs en Agriculture*, 22-23 Oct., Montpellier, France).
14. Biodiversidad de Agromyzidae (Diptera) en el Parque Natural de Sierra Nevada (Oral Communication – *XXVI Jornadas de la Asociación Española de Entomología*, 12-15 Sept., 2009, Granada, Spain).
15. El género *Pseudonapomyza* (Diptera: Agromyzidae) en el Parque Natural de la Tinença de Benifassà: novedades faunísticas (Poster Communication – *XXVI Jornadas de la Asociación Española de Entomología*, 12-15 Sept., 2009, Granada, Spain).
16. Dinámica ecológica del género *Pseudonapomyza* (Dptera: Agromyzidae) en la Comunidad Valenciana: efecto de la temperatura y de la pluviometría (Poster Communication – *XXVI Jornadas de la Asociación Española de Entomología*, 12-15 Sept., 2009, Granada, Spain).
17. Presencia de una nueva especie de interés económico en Europa: *Melanagromyza sojae* Zehnter, 1900. (Poster Communication – *VI Congreso Nacional de Entomología Aplicada. XII Jornadas Científicas de la SEEA*, 19-23 Oct., 2009, Palma de Mallorca, Spain).

General introduction 1

The taxonomic hierarchy of the Diptera family known as Agromyzidae is included within the Suborder Cyclorrhapha, Series Schizophora and Section Acalyptrata (OLDROYD, 1970) (Fig. 1-1), included within those families of flies that have reduced the size of their antennas and achieved a high degree of specialization as miner flies of plants.

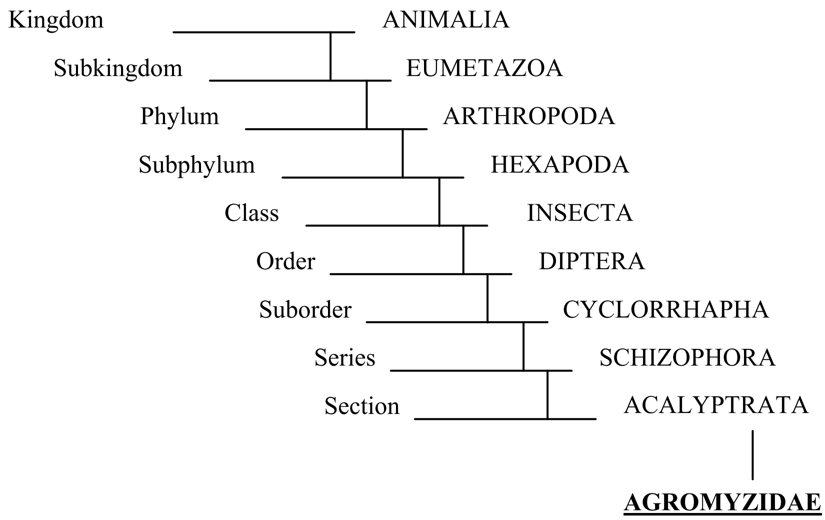


Figure 1-1. Taxonomic tree of the family of Agromyzidae Diptera (OLDROYD, 1970).

The Agromyzidae family (commonly known as leaf-miners) are a large and diverse family of flies composed exclusively of phytophagous species. Their host-plants range from wild to cultivated species, thus constituting an important group of pests in agriculture.

All Agromyzidae species undermine the internal tissue of different organs of plants. Depending on their eating habits they can be classified as leaf miners (leaf-mining), stem miners (stem-mining and tunneling), cambium miners, and parasites of flower buds or fruits.

The behaviour of phytophagous larvae of Agromyzidae is shared by other families of dipterans as Tipulidae, Cylindrotomidae, Sciaridae, Cecidomyiidae, Bibionidae, Anthomyzidae, Chloropidae, Drosophilidae, Tephritidae, Scathophagidae and Anthomyiidae. Diptera larvae can attack most of the organs of plants, but in most cases there is a degree of specialization. Leaf-mining is the behaviour most prevalent within the Agromyzidae family, but is comparatively rare for the rest. *Cylindrotoma distinctissima* (Meigen) (Cylindrotomidae), some Chloropidae and Anthomyzidae are usually found hidden among the leaves of grasses, but it is more common to find species attacking roots as in the Tipulidae, Sciaridae and Bibionidae families.

Most larvae of phytophagous diptera live inside the plants. Organs affected include practically the entire plant including leaves, stems, roots, cambium, seeds and flower buds. In addition, some species are inducers of the formation of gills in most parts of plants such as genus *Hexomyza* Enderlein.

Leaf-mining is the most widespread behaviour within Agromyzidae and this fact is why practically all species discovered until the mid-twentieth century corresponded to leaf-miners. This is the main preference of Agromyzidae and the damage is more easily detected visually. In 1950, approximately 900 species were known worldwide of which 90% corresponded to leaf-miners. Currently, about 2900 worldwide species are known of which 42% have known host-plants belonging to 146 genera and 899 botanical families (BENAVENT-CORAI *et al.*, 2005a). Nearly 60% of miners with known host-plants are leaf-miners, while the rest is mainly stem-miners.

Morphologically there is some discrepancy in its proximity to other families of Diptera. Personally, one of the families with the greatest resemblance to certain species of Agromyzidae are Cloropidae dipterans. HENNING (1958) considered that the closest family of dipterans is probably Odiniidae, while GRIFFITHS (1972) indicates the Clusiidae family as a sister-group of Agromyzidae. Clusiidae larvae mainly feed on rotting wood such as *Phytobia* Lioy, 1864 genus included in the most primitive Agromyzidae miners.

The largest contribution to the study of Agromyzidae biodiversity is due to authors F. HENDEL (Germany), T. BECKER (Germany), K.A. SPENCER (England), G.C.D GRIFFITHS (Canada), M. MARTINEZ (France), M. SASAKAWA (Japan), M. BEIGER (Poland), J.T. NOWAKOWSKI (Germany), S.A. PAKALNISKIS (Lithuania), L. SÜSS (Italy), V.V. ZLOBIN (Russia) and M. CERNY (Czech Republic). Bibliographically greater contents focus on studies that seek ways to address the control of agromyzid populations with economic interest. Although substantial efforts have been made in advancing the knowledge of the global composition of Agromyzidae species, there is a significant lack of knowledge in most areas of Europe, North Africa and the Asian part of the Palaearctic Region (CERNY & MERZ, 2006).

The significant lack of knowledge in about half the world's Agromyzidae biodiversity (MARTINEZ comm. pers.) is due to the great difficulty involving this family. Few systematic entomologists have ventured to study and get to know this family, thus it lacks most terrestrial regions. The small size of specimens, generally between 1.5-2 mm and the close proximity between morphological species are the main causes.

The confusion in the nineteenth century was due to the high similarity between Agromyzidae individuals that introduced a high number of synonyms. HENDEL (1918) clarified much of the errors introduced by the association of the miners to their host-plants, because he realized the enormous monophagy that exists in this family. In contrast to the high proportion of species which are restricted in their feeding to a single family or genus, only 16 species (0.6% of the total) are truly polyphagous, feeding on a number of unrelated families (SPENCER, 1990). HERING (1951) studies confirmed that most species of Agromyzidae are monophagous or oligophagous.

The greatest progress made within the family Agromyzidae is due to the studies conducted by K.A. SPENCER in his nearly 200 publications dedicated to the systematic study of Agromyzidae. The major contribution of SPENCER to the progress of the Agromyzidae knowledge was the specific characterization through the study of the male genitalia. Also addressed by FRICK (1952) in the United States and SASAKAWA (1961) in Japan. The development of a protocol for extracting the genitalia, their design and characterization have revealed hundreds of new species without the need to rely on the knowledge of their host-plants. After the boom in studies of the male genitalia, nearly all systematic works include the morphology of the reproductive organ.

Usually the morphological interpretation of the genitalia requires extensive experience, and inexperienced entomologists make commonly systematic errors. This is the reason why usually the identifications are also confirmed by studying the external morphology, although in some cases is not enough. At present advances in studies of molecular biology are enabling rapid progress on the identifications because of the creation of databases within the "Barcoding" projects.

In Spain there are few studies which contribute to the present knowledge of the Agromyzidae biodiversity. The occurrence of 317 species (including Balearic and Canary islands) of Agromyzidae is cited from Spain in the present thesis (See Annexe 1). Existing studies are focussed mainly on a few authors highlighting the studies of BENAVENT-CORAI *et al.* (2004, 2005a, 2005b), CERNY (2004, 2006), CERNY & MERZ (2006), CERNY & VALA (2006), CZERNY & STROBL (1909), BEZZI (1912), ECHEVARRÍA (1996), ECHEVARRÍA *et al.* (1994), FRANCÉS (1994), STROBL (1900, 1906), GRIFFITHS (1967a, 1963), HERING (1943, 1955), SPENCER (1957, 1960, 1966b, 1969, 1972a, 1973) and ZLOBIN (2002b).

The Department of Entomology and Pest Control of the University of Valencia has focused historically on the study of parasitoids. The contribution to the studies of the Agromyzidae parasitoids has allowed better knowledge of the biology of Agromyzidae, as well as others important ecological factors. The main examples are the works done by AVINENT *et al.* (1988), CABELLO *et al.* (1993, 1994), CABELLO & BELDA (1992), DOCAVO (1955, 1960, 1962, 1965, 1984, 1985, 1986, 1987), DOCAVO *et al.* (1985a, 1985b, 1987a, 1987b), FRANCÉS (1988), FRANCÉS & JIMÉNEZ (1989a, 1989b, 1989c), JIMÉNEZ (1983b, 1985, 1988), JIMÉNEZ *et al.* (1990), JIMÉNEZ & TORMOS (1987, 1988, 1990), PARDO *et al.* (2000, 2001), PASCUAL *et al.* (1992), PEÑA (1983, 1985, 1988), PEÑA & RODRÍGUEZ (1984), SÁIZ (1976), TORMOS (1986), TORMOS *et al.* (2003) and VERDÚ (1989).

Agronomic importance of Agromyzidae 2

The first appointments of agromyzid damage in plants date from the eighteenth century, when RÉAMUR (1738) illustrated the damage produced in leaves of *Sonchus oleraceous* L., *Trifolium*, *Ranunculus* and *Lonicera*. CURTIS (1844, 1845, 1846) was the first author in citing the Agromyzidae damage in plants grown as *Viola*, *Phlox*, *Cineraria* and *Ilex aquifolium* L. in England. RATZEBURG (1868) cites the larval damage of Agromyzidae on trunks of *Acer platanoides* L. in Russia. While RONDANI (1875) was the one who first described a species of Agromyzidae, *Liriomyza cicerina* attacking *Cicer arietinum* L. Subsequently, other Agromyzidae species undermining different crops were reported like *Cerodontha (Poemyza) lateralis* (Macquart, 1835) damage on wheat and barley (LINDEMANN, 1886), the damage to beans produced by *Ophiomyia phaseoli* (Tryon, 1895), and the damage on *Asparagus* produced by *Ophiomyia simplex* (Loew, 1869) (SAJÓ, 1896).

At present, there are species of Agromyzidae particularly harmful to crops. In this sense, BURGESS (1880) described the damage caused by *Liriomyza trifolii* on *Trifolium repens* L. and later RILEY (1884) described the damage caused by *Liriomyza brassicae* on cabbage leaves. These together with other species were proliferating until damage level was considered pest like. The development and improvement of cultivation technology has favoured the presence of cultivated plants more succulent and susceptible to damage by Agromyzidae. Facilitation of the plant growth in a forced way has increased the existence of pests in greenhouses such as *Phytomyza chrysantemi* Kowarz (LINTNER, 1891). International trade of plants was another important factor that triggered the proliferation of dangerous polyphagous species among countries.

Since 1915, the largest entomological knowledge of Agromyzidae made the number of described species of plants increase significantly. Any species that cause damage to plants can become pests always exceeding the threshold of economic damage of the crops. The damage done depends on the organ attacked, the state of plant development when the damage occurs and the population size. However, consideration of pest species is conditioned by economic thresholds established by man and by the preference of those species that have been chosen for their cultivation. In many cases the quality controls present in the current European legislation reject those plant products with important aesthetic damage generating non-marketable products. The trend to monoculture and intensive farming results in greater pressure on the proliferation of certain species adapted to the specific conditions of plants and environment.

Under normal conditions most of the populations of Agromyzidae are well controlled by their natural enemies (Braconids: Ichneumonoidea, subfamily Alysiinae-Dacnusini and Opiini tribes; Chalcids: families Eulophidae and Pteromalidae, and Cynipids: family Eucoilidae) (SPENCER, 1973), although in many cases they do not become fully effective to prevent the threshold for damage. The life cycle of natural enemies in many cases is disturbed by the presence of pesticides on plants or the environment, pollution, climatic conditions or due to an asynchrony in times of predator and host emergency.

It is assumed that chemical treatments provide reliable and immediate results, and can furthermore be administered more efficiently with regard to timing and economic aspects. Nevertheless, treatments with pesticides are not easily harmonised with other control methods and may have certain unpredictable -known or unknown- environmental effects (DARVAS & POLGÁR, 1998). Due to the short duration of the effective control and the hidden mode of live of larvaes, a significant portion of chemical treatment might remain ineffective. The primary reason is that the active ingredients used today show pure systemic and translaminar action (or even non-systemic), so their penetration into plant tissue and translocation is limited.

The proliferation of modern synthetic insecticides has propitiated and allowed the emergence of many species such as *Liriomyza huidobrensis* (Blanchard, 1926) and *Liriomyza sativae* Blanchard, 1938. The case of the most serious environmental impact was the use of the organochlorine DDT (Dichloro-Diphenyl-Trichloroethane) prohibited since 1986 in Spain by their detrimental effects on the immune system thus producing the death of birds. The long-term administration of DDT has resulted in animals with hepatic, renal and immune effects. DDT prevents the androgen receptor and produces its blocking, so instead of the androgen drives for a normal sexual development in male rats, it causes abnormalities. In laboratory cultures of phytoplankton from the entire Caspian Sea to the Mediterranean, the DDT at a concentration of 1 ppb reduced primary production up to 50%. The long-range atmospheric transport of DDT in northern countries, including the Arctic, is well documented, DDT has been detected in Arctic air, land, ice and snow and virtually all levels of the Arctic food chain. Many studies indicate that the bottom sediments in lakes and rivers act as reservoirs for DDT and its metabolites. In 1968 a strong proliferation of alfalfa leaf-miners was correlated in a pre-treatment made with diazinon (JENSEN & KOEHLER, 1970).

These negative experiences has favoured the development of alternative methods since the late nineteenth and early twentieth centuries, focusing the most part of the research on finding an effective means of control compatible with the maintenance of the ecological balance. Control alternatives used for phytophagous Diptera include a great number of strategies. We can sum up as: a) Agricultural methods: selection of the habitat and preceding crop, soil cultivation and fertilisation, choice of crop species and varieties, sowing time, crop density and depth of planting, time of harvesting, shoot selection and cutting; b) mechanical methods; c) physical methods; d) forecasting: netting, colour and odour traps, traps containing sex pheromone and attractants, application of trace of premature feeding females; e) chemical methods: poisoned bait, zoocides (chlorinated hydrocarbons, organophosphorous compounds, carbamates, pyrethroids, etc.), insect development and reproduction disrupters, insecticide resistance and its management; f) biological methods: enthomopathogenic nematodes, predators and parasites; g) parabiological methods: entomopathogen microorganisms, genetic methods, biotechnological methods; and g) integrated control.

The most recent systems for the control of Agromyzidae pests are the use of insecticides (HOSSAIN & POEHLING, 2006a; RAMESH & UKEY, 2007; SARADHI & PATNAIK, 2006; WANG *et al.*, 2006; WEINTRAUB & MUJICA, 2006; WU *et al.*, 2007), the improvement of host varietal resistance (JADHAV *et al.*, 2006; SHARMA *et* *al.*, 2007; WU *et al.*, 2006), the use of parasitoids (HESAMI *et al.*, 2006; TELLEZ *et al.*, 2006; TOKUMARU & ABE, 2006; TRAN *et al.*, 2006; YANG *et al.*, 2005) and bacteriums (TAGAMI *et al.*, 2006).

In spite of frequently observed resistance against insecticides, especially in some *Liriomyza* species (PARRELLA *et al.*, 1981; PARRELLA & LINDQUIST, 1983), chemical treatments are in many cases indispensable. The use of abamectin and the insect growth regulator cyromazine seem to be effective against many leaf miners.

In greenhouses, biological control by cumulative release and support of parasitoids is widely applied. Parasitoids active against several agromyzid pest species in greenhouses (mainly *Liriomyza*) are commercially available. Most of the parasitoids are quite unspecific and can be applied for several agromyzid pests, even in different genera (MINKENBERG & VAN LENTEREN, 1986 and references therein, BENUZZI & RABONI, 1992 and van der LINDEN, 1992).

A number of parasitoids were actively introduced into areas where alien agromyzids have established themselves (HARCOURT *et al.*, 1988; WATERHOUSE & NORRIS, 1987). However, because of various reasons these introductions are often not successful. MURPHY & LASALLE (1999) argued, instead of introducing foreign species, native parasitoids with the potential to adopt the newly invaded agromyzids should be supported. However, as already indicated, the effectiveness of parasitoids can be strongly diminished by the application of insecticides to control agromyzids or other pest insects.

The second important attempt in biological control of Agromyzidae is breeding resistant or pest-tolerant plants. This route was extensively pursued to protect tropical beans and peas (SHANOWER *et al.*, 1999; TALEKAR, 1990). However, resistant accessions often failed to be economically successful because the taste and quality of most of them are often inferior to susceptible ones (WATERHOUSE, 1998).

Not much research has been done on the parameters that repel agromyzids to the develop on a certain plant. The females of several species are deterred from oviposition by dense trichomes on the leaf surface (CHIANG & NORRIS, 1983a; FAGOONEE & TOORY, 1983).

Other parameters influencing the well-being of the larvae can be stem diameter, leaf area, water content and chemical characteristics (CHIANG & NORRIS, 1983a; CHIANG & NORRIS, 1983b; CHIANG & NORRIS, 1983c; TALEKAR *et al.*, 1988; WEI *et al.*, 2000).

The knowledge of the bionomics of flies and their relation to the host-plants might give some clues to the protection of cultural plants. For example, alternative host-plants could be removed from the vicinity of the plantations; if the larvae are known to pupate in the host-plants, the leaf litter remaining after harvest should be strictly removed from the field. Such measures can often be lower than the agromyzid abundance of the subsequent generation.

Young bean plants infested by *Ophiomyia phaseoli* (Tryon, 1895) are particularly vulnerable, because the larvae often destroy vascular tissue near the root.

Only those plants, which manage to develop adventitious roots above the destroyed tissue have a chance to survive. Plant survival can considerably be improved by irrigation and planting in furrows filled with soil, thus facilitating the growth of adventitious roots (TALEKAR, 1990).

Although the best known damage caused by Agromyzidae is the formation of galleries, it is also very common to see the discoloration and drying of various plant parts (especially leaves) usually produced by females like food punctures. As many as 100 feeding punctures were observed in a single leaf of spinach in California (WILCOX & HOWLAND, 1955).

Damage caused by Agromyzidae leads to a reduction in the photosynthetic capacity of plants for decreasing the active area of tissue of the leaves, reducing their metabolism and vigour. The aesthetic damage caused by the visible mines can greatly reduce the value of a large number of plants making them unfit for marketing. Stems from the miners may even be more dangerous to affect the vascular tissue and therefore the transport of nutrients through the plant. Mines and punctures caused by feeding and oviposition favour the development of diseases of bacterial and fungal origin.

If damage occurs to cultivated plants, Agromyzidae larvae can cause important yield decreases and even produce the death of plants. The economic impact is particularly important when the damage is caused by extremely voracious polyphagous species such as *Liriomyza trifolii* (Burgess in Comstock, 1880), *L. huidobrensis* (Blanchard, 1926), or *Chromatomyia horticola* (Goureau, 1851), species dispersed virtually all over the world.

Apart from the leaf-miners that comprise approximately 60% of Agromyzidae miners with known host-plants, there are another large and growing number of Agromyzidae damages produced in stems, roots, fruits and flower buds. The genus Agromyzidae with the most importance like stem-miners is *Phytobia* with 17 species at Palaearctic level. Some examples of stems miners of economic importance are *Melanagromyza obtusa* (Malloch, 1914) (infesting pods of *Cajanus indicus* Spreng.) *Melanagromyza chalcosoma* Spencer, 1959 and *Melanagromyza vignalis* Spencer, 1959 (occurring in tropical Africa on *Cajanus* and *Vigna*). SPENCER (1973) cites important miner species of roots like *Melanagromyza fabae* (mining in broad beans), *Ophiomyia lappivora* (Koizumi, 1953) (mining in *Arctium lappa* L.), *Liriomyza braziliensis* (Frost, 1939) (feeding in potato tubers in South America), *Napomyza carotae* (damaging carrots), *Ophiomyia phaseoli* (Tryon, 1895), *Ophiomyia spencerella* (Greathead, 1969) (mining roots of beans) and *Napomyza scrophulariae* Brischke, 1881 (damaging *Digitalis*).

About 5% of the world Agromyzidae fauna feed on cultivated plants and can cause considerable damages and economic losses. DEMPEWOLF (2004) cites the presence of 117 Agromyzidae species considered of economical importance.

The work of SPENCER (1973), PARRELLA (1987) and MARTINEZ (1993) are the main studies that include most Agromyzidae species of economic importance in Spain. BENAVENT-CORAI *et al.* (2004) summarizes the works and increases the number of species of agronomic interest to 53 by the citation of *Melanagromyza fabae* (1973). In Spain, in the early twentieth century, Agromyzidae species which damage chickpeas are cited for the first time (Del CAÑIZO, 1934; NAVARRO, 1903). In this thesis is cited *Melanagromyza sojae* (Zehnter, 1900) like a new pest for Europe, found in Spain.

From 1973-1982, the Nearctic *Liriomyza trifolii* (Burgess in Comstock, 1880) species was moved to *Liriomyza bryoniae* (Kaltenbach, 1858) and *Liriomyza strigata* (Meigen, 1830) (CABELLO *et al.*, 1990 and MORENO *et al.*, 1993), which until then were common species in greenhouses (CADAHIA, 1983; ESTRADA-CABEZA, 1986; RODRÍGUEZ 1988). The introduction of *L. trifolii* damage resulted in an important reduction of the production (BELDA, 1991; CABELLO *et al.* 1990; MORENO *et al.*, 1993 and PEÑA, 1986). Finally, in 1990, another Nearctic agromyzid, *L. huidobrensis* (Blanchard, 1926) was cited in Spain (PASCUAL *et al.*, 1992) and has gone about increasing their damage importance to bean crops, tomatoes, peppers and melon (CABELLO *et al.*, 1993, 1994). The Agromyzidae importance in our country is also significant in cultures established outdoors, whose attacks have been extremely severe in the late eighties and early nineties (ECHEVARRÍA *et al.*, 1994).

Special agronomic importance have certain genera which include species like the polyphagous *Liriomyza*, *Ophiomyia*, *Chromatomyia* and *Phytomyza*. In Europe, *Chromatomyia horticola* and *Liriomyza trifolii* are widely distributed outdoors. In greenhouses predominate *L. bryoniae*, *L. huidobrensis*, *L. strigata* and *L. trifolii* (CABELLO *et al.*, 1994).

Proper identification of species is an important prerequisite for effective control and the establishment of quarantine measures, especially when measures are included into integrated pest management or biological control. The taxonomic confusion is the main problem for establishing the pest control (PARRELLA & KEIL, 1984). This is because close species can have different food habits or present different hosts. The Agromyzidae family is considered the most taxonomically difficult between dipterans, due to the high degree of uniformity between species and the small size of specimens (normal size is 2-2.5 mm).

Significant efforts must be made to increase the speed of identifications so that swift action of the pest control measures is established. The tool that will probably be used for this purpose is the use of genetic libraries constructed on the basis of molecular biology techniques.

Objectives 3

The aim of this study is part of a project of tritrophic interactions plant-phytophagous-parasitoid. For this, three Natural Parks of Community of Valencia were selected namely (“Tinença of Benifassà”, “Font Roja” and “Laguna de La Mata-Torrevieja”), chosen for their particular environmental conditions.

The main objective of this thesis is the training specialization of the doctoral student in the systematic knowledge, wildlife and ecology of the Agromyzidae (Diptera) family. For this purpose, the captured specimens with Malaise trap throughout 2004-2007, and the mined fresh material collected in a parallel study will be used.

The following objectives are proposed:

1. A systematic study of adult and reproductive structures with particular reference to the structure of the genitalia of male Agromyzidae allowing the identification of material collected.

2. A taxonomic study of the Agromyzidae species in each of the Natural Parks. This will enable the assessment of the biodiversity of the areas studied, based on the citation of new species in our territory and those not yet described.

3. Systematic, faunistic and phenologic characterization of the species, emphasizing the agronomic interest on the basis of their monophagy and polyphagy.

4. Study of alpha, beta and gamma biodiversity in the Natural Parks studied by the use of biodiversity indicators and the approximation of the captures to different statistical models.

5. Bitrophic study of Agromyzidae interaction with their host-plants. These will permit a completion of the catalogue of host-plants of Agromyzidae based on the knowledge of the flora undermined by Agromyzidae in Eastern Spain.

Faunistic composition of Agromyzidae genera 4

4.1 Palaearctic composition of Agromyzidae genera

Agromyzidae genus within the Palaearctic region consists of 24 genera constituting a total of 1160 species (Fig. 4-1). It is noted that 4 genera (*Phytomyza*, *Liriomyza*, *Cerodontha* and *Agromyza*) support 61.6% of the total known species in the region, highlighting the specific composition of *Phytomyza* (28.4%) genus.

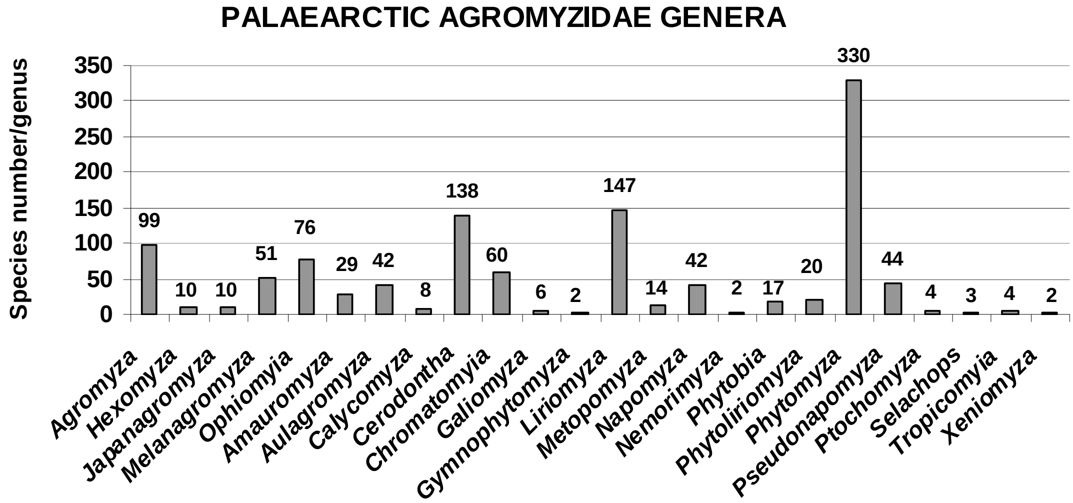


Figure 4-1. Quantitative genera composition of Agromyzidae family in the Palaearctic region.

In a second genera group consisting of a number of species between 50-100 are *Melanagromyza* (4.4%) and *Chromatomyia* (5.2%). Both genera constitute 9.6% of the Agromyzidae biodiversity.

Among the genera that have a number of species from 10-50 are *Hexomyza* (0.9%), *Japanagromyza* (0.9%), *Amauromyza* (2.5%), *Aulagromyza* (3.6%), *Metopomyza* (1.2%), *Napomyza* (3.6%), *Phytobia* (1.5%), *Phytoliriomyza* (1.7%) and *Pseudonapomyza* (3.8%). Overall contribution to the biodiversity of this genera group is 17.2%.

Finally, there are 8 genera consisting of a small number of species below 10. This group includes *Calycomyza*, *Galiomyza*, *Gymnophytomyza*, *Nemorimyza*, *Ptochomyza*, *Selachops*, *Tropicomyia* and *Xeniomyza*. Overall they constitute 2.2% of the species of Agromyzidae.

Figure 4-2 summarizes the percentage of species distribution within the known Agromyzidae genera in the Palaearctic region. It is noted that most genera support less than 10% of all known species with only *Phytomyza* (28%), *Liriomyza* (18%), and *Cerodontha* (12%) genera that exceed this percentage.

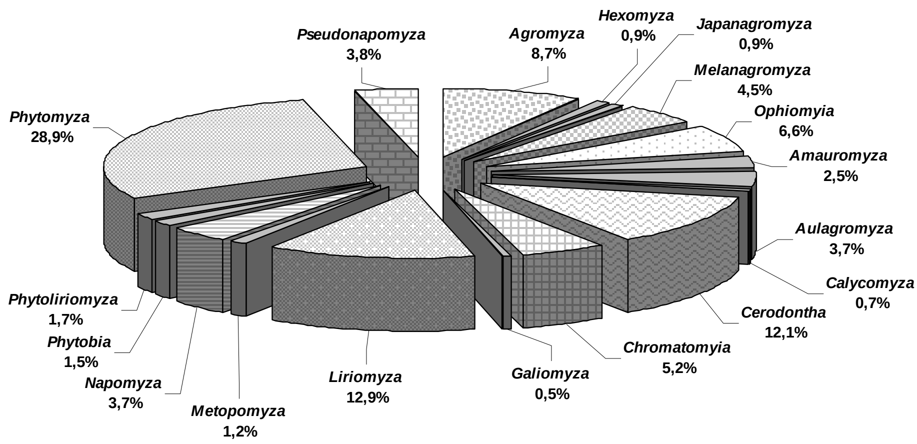


Figure 4-2. Known genera percentage composition of Agromyzidae in the Palaearctic region.

The fact that few Agromyzidae genera support a lot species means that identification is very complicated. The small size of individuals and the great morphological uniformity among species makes this family of flies one that presents the greatest difficulty taxonomic.

4.2 Southwestern European Agromyzidae genera composition

It has been considered desirable to restrict the study to the southwest of Europe. For its limitation we have used the approach of the United Nations Statistics Division, which divides the western region of Southern Europe into 18 countries (Fig. 4-3).

The west of Europe consists of Austria, Belgium, France, Germany, Luxembourg, Monaco, Switzerland and The Netherlands. While the south is composed of Andorra, Bosnia-Herzegovina, Cyprus, Greece, Italy, Macedonia, Portugal, Serbia-Montenegro, Slovenia and Spain.

MARTINEZ (2004) shows the quantitative composition of Agromyzidae species in the Southern and Western Europe countries. It is noted that regions with the highest number of known species are concentrated in areas where historically there have been more interest in the Agromyzidae diptera family. Specifically recent studies increase the number of known species in many of the countries listed: Andorra (CERNY, 2007); Switzerland (CERNY & MERZ, 2005); Italy (CERNY, 2006); Cyprus (CERNY & VALA, 2006); also Austria, Croatia, France, Germany, Greece, Macedonia, Portugal and Switzerland (CERNY & MERZ, 2006).

Figure 4-3. Contemporary statistical regions of Europe as delineated by the United Nations (Resource: *www.wikipedia.org*).

The countries studied belonging to the Western region of Europe, specifically Germany, France and Austria. In the Southern regions of Europe are highlighted Spain and Italy, overcoming the number of known species in Belgium, The Netherlands, and Switzerland. The remaining countries are not extensively studied, highlighting the recent increase fauna of Agromyzidae in Andorra (91 species) and Greece (21). However, there is an uneven knowledge of Agromyzidae in neighbouring regions, which is an important indicator of the significant effort required to get to know the actual distribution of Agromyzidae in Europe. The significant lack of much of the Agromyzidae biodiversity in Europe is also known (von-TSCHIRNHAUS, 1999).

Figure 4-4 shows the quantitative composition of species in the Southwestern region of Europe. The country with the largest number of species is Germany (560), followed by France (361), Spain (287), Italy (280) and Austria (237). In a second group of countries much less studied had Andorra (92), Greece (38), Portugal (30), Slovenia (13) and Croatia (11). Finally the remaining countries, includes Macedonia (3), Cyprus (2), Monaco (2), Bosnia-Herzegovina (1), Serbia-Montenegro (0) and Luxembourg (0), having been studied very little or none at all.

The most systematic work that represent the Agromyzidae family in countries with higher fauna representation is as follows: Germany (BROWN, 2007; ENDERLEIN, 1936; GEISSERT, 1981; GIBBS & von-TSCHIRNHAUS, 2006; GRIFFITHS, 1964a, 1964b, 1966, 1967a, 1968a, 1968b, 1984; HANSSON, 1985; HENDEL, 1926, 1927, 1932; HERING, 1935a, 1935b; MARQUARDT, 1985; NOWAKOWSKI, 1972; SPENCER, 1966a, 1966b, 1969, 1971; STRAUS, 1977; STRESEMANN *et al.*, 1990; von-TSCHIRNHAUS, 1969, 1981, 1992 and ZIEGLER & MENZEL, 2000), France (D'AGUILAR & MARTINEZ, 1979; DELPLANQUE, 1998;

GRIFFITHS, 1963; HERING, 1943; MARTINEZ, 1982; MARTINEZ, 1987; MARTINEZ & SOBHIAN, 2000; NOWAKOWSKI, 1967 and CERNY & MERZ, 2007), Spain (CERNY & MERZ, 2007; CZERNY & STROBL, 1909; DOCAVO *et al.*, 2001; ECHEVARRIA *et al.*, 1994; GRIFFITHS, 1963, 1966, 1967b, 1968a; HERING, 1943; PARDO *et al.*, 2001; PASCUAL *et al.*, 1992; SPENCER, 1966b, 1969; STROBL, 1909; TORMOS & SENDRA, 1989, TORMOS *et al.*, 2003 and ZLOBIN, 2002b), Italy (BOSIO, 1994; GRIFFITHS, 1966, 1967a, 1968b; PRIORE & TREMBLAY, 1993, 1994, 1995; SPENCER, 1965, 1966b; SÜSS, 1979, 1984, 1987, 1989, 1991 and SÜSS & MORESCHI, 2005), Austria (CHANDLER, 1998; ENDERLEIN, 1936; FISCHER, 2004, 2005; GRIFFITHS, 1966, 1980; HENDEL, 1932; MIK, 1887; NOWAKOWSKI, 1967; SPENCER, 1966b, 1969 and STROBL, 1893, 1909), Andorra (ENDERLEIN, 1936 and CERNY, 2007), Greece (HANSSON, 1985; LOEW, 1869; SOULIOTIS & SÜSS, 2004; STROBL, 1902 and ZLOBIN, 2001, 2002a) and Croatia (ENDERLEIN, 1936 and KOMNENOVIC & PAGLIARINI, 1981).

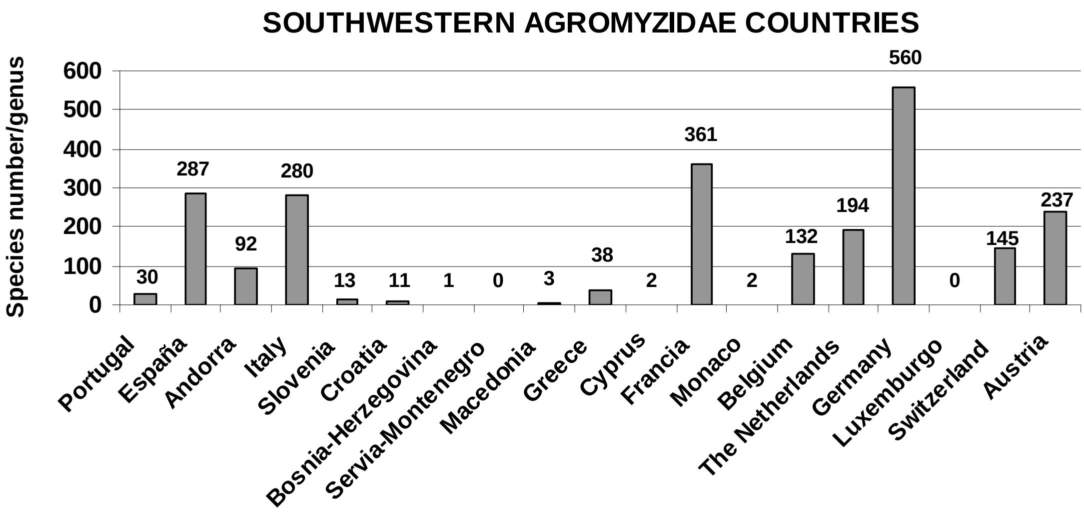


Figure 4-4. Quantitative species composition of Southwestern European countries.

Figure 4-5 quantitatively represents the number of species within each genera in the Agromyzidae area of Southwestern Europe. Notes that remain *Phytomyza* (228), *Liriomyza* (94), *Agromyza* (72) and *Cerodontha* (69) genera bearing the greatest number of species representing 66.33% of the total species of Agromyzidae.

In a second group of genera based on their abundance are *Chromatomyia* (42), *Ophiomyia* (41), *Melanagromyza* (28), *Aulagromyza* (27) and *Amauromyza* (16). The rest of the Agromyzidae genera have a number of species equal to or less than 15. Meaning that of the total of 24 known genera almost all of the species are concentrated in 1/3 of them. A major effort should be made to get to know the real species content within each genus.

Figure 4-6 represents the percentage composition of Agromyzidae for each genera. It is noted that the distribution is very similar to that obtained for the whole of the Palaearctic region. This goes to show that the regions of Southwestern Europe are more extensively studied than the Northeast, historically represented by fewer systematic entomologists specialists in the family Agromyzidae. However, the local climate of the areas of Northern Europe means the cultivation in climate greenhouses is widespread, which makes the number of studies of Agromyzidae mainly focused in the control of populations in controlled environments.

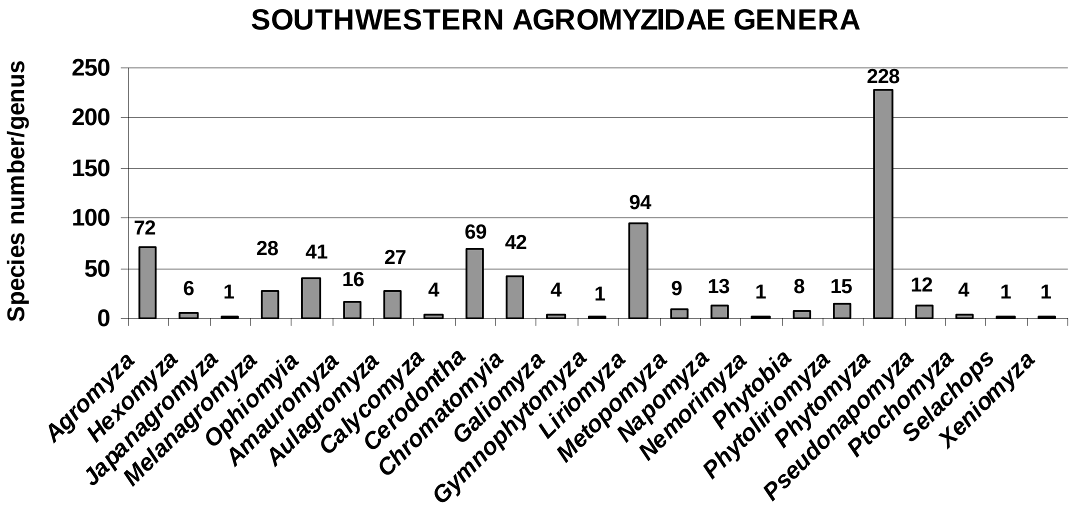


Figure 4-5. Quantitative genera composition in the Southwestern European countries.

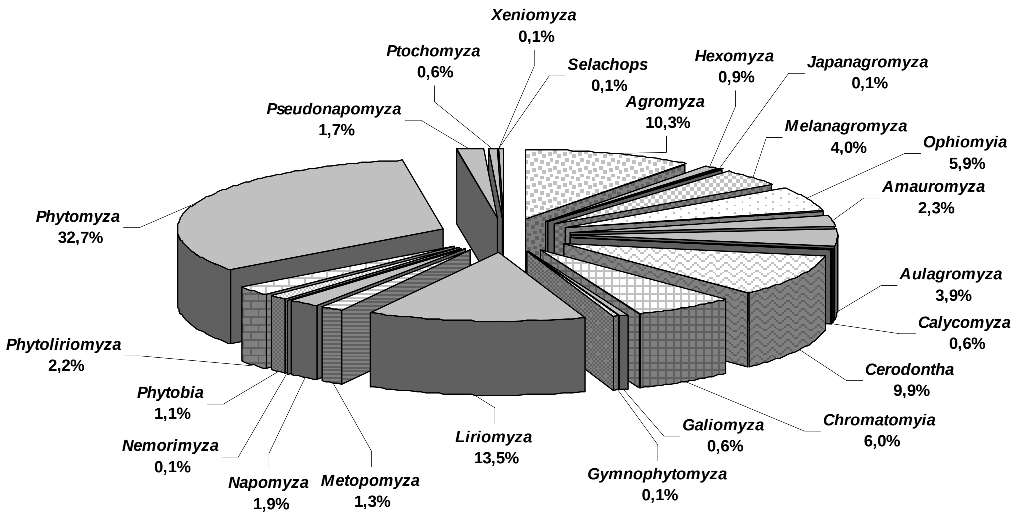


Figure 4-6. Known genera percentage composition of Agromyzidae in the Southwestern region.

4.3 Spanish Agromyzidae genera composition

The genera best represented of the Agromyzidae fauna from Spain correspond fairly well with those obtained for Southwestern Europe. However, the quantitative difference of species into genera is relatively small. In this way, the quantitative composition of the number of species within genera best represented is as follows: *Phytomyza* (50), *Liriomyza* (44), *Agromyza* (38) and *Cerodontha* (34). They overall represent 60.6% of all known Agromyzidae species (Fig. 4-7).

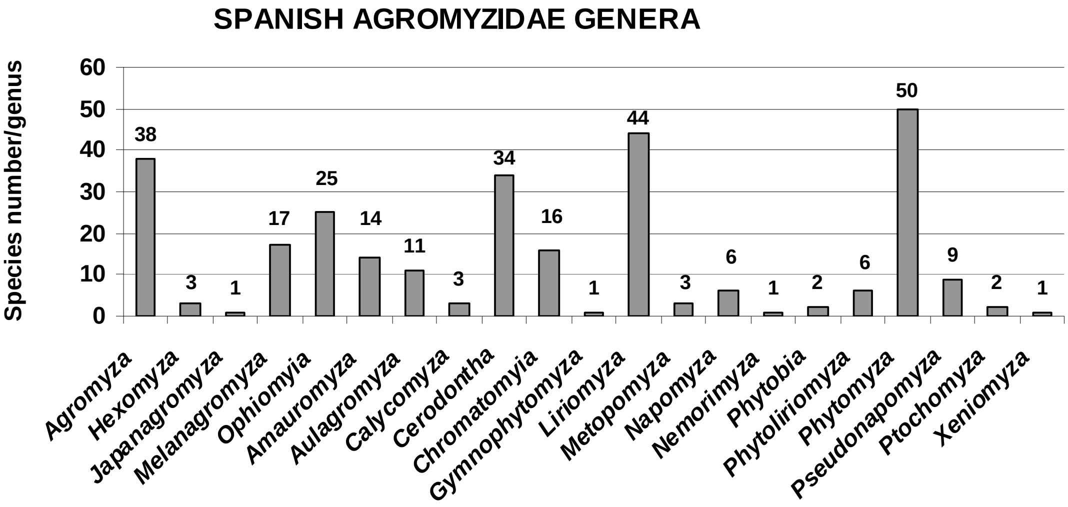


Figure 4-7. Quantitative genera composition of Agromyzidae in Spain.

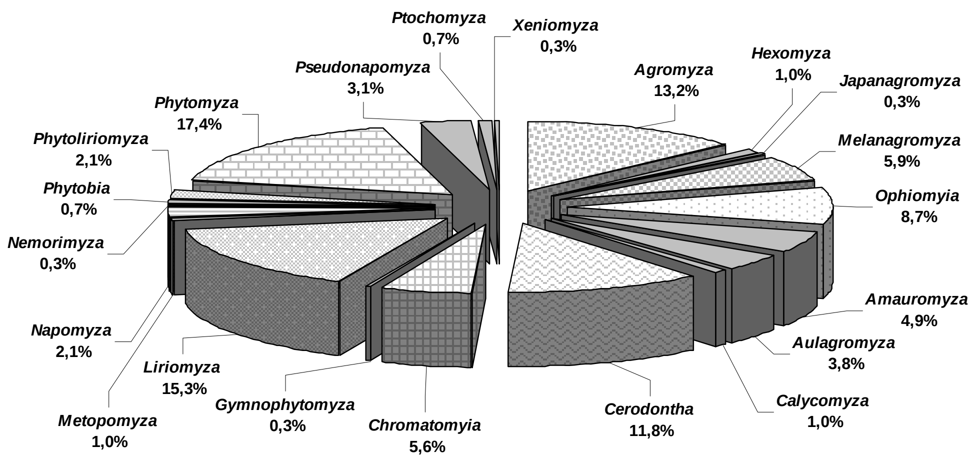


Figure 4-8. Known genera percentage composition of Agromyzidae in Spain.

The remaining species are mainly focused on genera *Ophiomyia* (8.8%), *Melanagromyza* and *Chromatomyia* (both 6.8%), *Amauromyza* (4.8%) and *Aulagromyza* (3.8%) (Fig. 4-8). The remaining genera is less than 3%. It highlights the important ignorance of the biodiversity that we have verified within *Pseudonapomyza* genus, in which we have noted the existence of at least 5 new species to science distributed in the Natural Parks of “Tinença de Benifassà”, “Font Roja” and “Lagunas de La Mata-Torrevieja”.

As a final conclusion one can say that better representative genera in each of the regions studied is fairly constant. Generally the percentage composition of species differs within each genera based on the sampling effort in each country. The greatest difficulty in locating new species is due to most species have low population levels, and polyphagous species are more easily captured and widely distributed by most anthropized areas.

4.4 Spanish biodiversity

According to MARTÍNEZ & BÁEZ (2002), the number of Agromyzidae species present in the Spanish fauna was 228. Subsequently, MARTINEZ (2004) updated this number to 245 in the European Fauna database.

Apart from the publications mentioned above, several new species discovered in Spain have been cited by different authors (CERNY, 2004; CERNY, 2006; CERNY & MERZ, 2006; CERNY & VALA, 2006; ZLOBIN, 2000; and ZLOBIN, 2002). Thus, the number of Spanish Agromyzidae species reach the figure of 265. The additions included in this thesis have updated the number of species from continental Spain to 287.

Systematic study of Agromyzidae 5

5.1 General aspects

Although Agromyzidae systematic studies included in this thesis have been carried out almost exclusively through the study of the external morphology of the adult (especially for the identification of females) and the study of the male genitalia, it was thought desirable to include other potential morphological tools for identification such as the female genitalia and immature stages of Agromyzidae (larval and pupal).

5.1.1 Adult external morphology

Agromyzidae family is characterized by having a great morphological similarity between the sexes, being practically impossible to reach the species level, in most cases, only using the external morphology. This greatly complicates the identification, existing in certain cases uncertainty to consider where is the species level. In cases where the host-plants are known identification is unequivocal because of the high monophagy existing within Agromyzidae. Otherwise, the Agromyzidae experience of systematic entomologists will determine the reliability of identifications. Progress in the field of molecular biology is particularly important for the Agromyzidae family, because they avoid misidentifications due to human factors and can be carried out by technical not specialists in systematics.

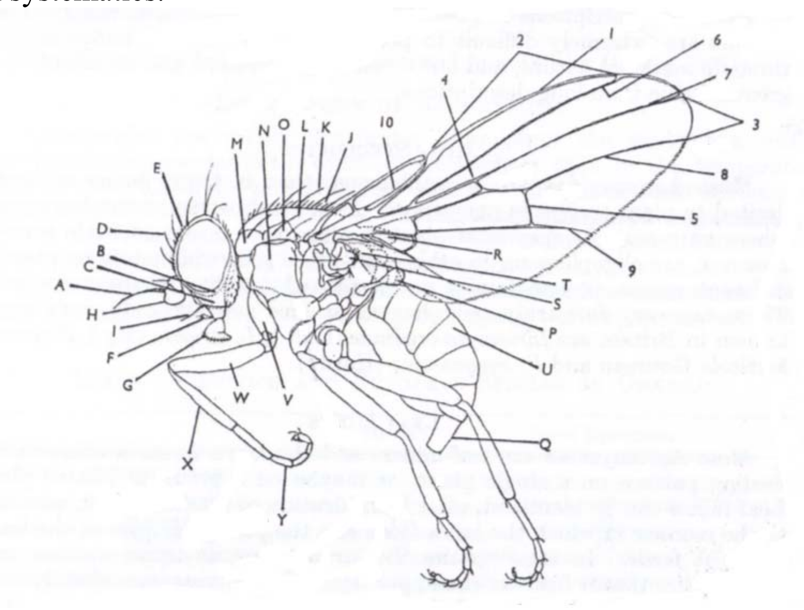


Figure 5-1. Typical Agromyzid in side view (SPENCER, 1973). A, arista. B, cheek. C, jowl. D, orbital bristles. E, orbital setulae. F, palp. G, proboscis. H, third antennal segment. I, vibrissa. J, acrostichals. K, dorso-central bristles. L, mesonotum. M, humerus. N, mesopleural area. O, notopleural area. P, haltere. Q, ovipositor sheath. R, scutellum. S, squama. T, squamal fringe. U, tergites. V, coxa. W, femur. X, tibia. Y, tarsi. Z, katapisternum. 1, costa. 2, second costal section. 3, fourth costal section. 4, first cross-vein. 5, second cross-vein. 6, R_{2+3}. 7, R_{4+5}. 8, M_{1+2}. 9, M_{3+4}. 10, R_1.

The classification and identification presented in this thesis are based on the terminology used by SPENCER (1972b, 1976a, 1976b). Figure 5-1 summarizes the external morphology of Agromyzidae indicating major morphological parts of the head, thorax, abdomen and wing venation.

Agromyzidae family is subdivided in two families (Agromyzinae and Phytomyzinae). In the Agromyzinae the subcosta is fully developed and joins vein R_1 before this reaches the costa (Fig. 5-2); most species are large and stout, with wing length of about 3 mm, and the costa generally extends strongly to vein M_{1+2}. In the larvae there is a third, upper arm of the cephalo-pharyngeal skeleton. In the Phytomyzinae the subcosta is greatly reduced, frequently being little more than a fold, running parallel to the subcosta and joining the costa independently; in several genera the costa is reduced and terminates at the apex of vein R_{4+5}. The largest species in the family occur in the primitive genus, *Phytobia* Lioy, 1864, but many species are smaller, more slender and even minute, with wing length of less than 2 mm. The cephalo-pharyngeal skeleton of the larva has only two arms (SPENCER, 1972b).

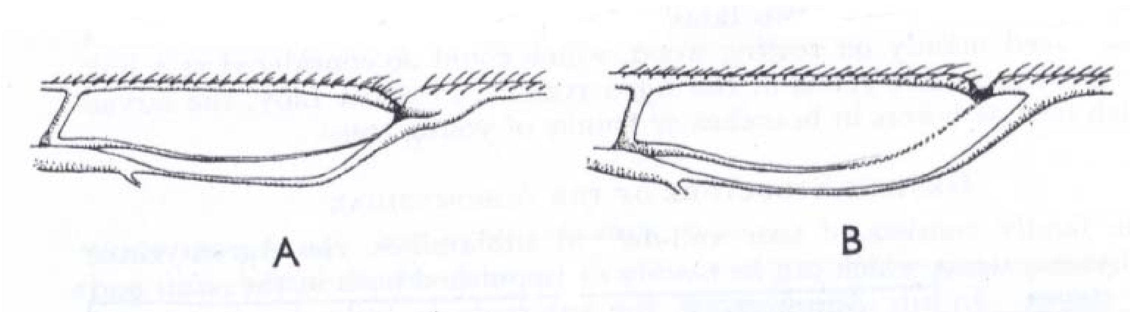


Figure 5-2. Sub-costa of (A), subfamily Agromyzinae; (B) Subfamily Phytomyzinae (Spencer, 1972b).

Morphology based on HENNIG, 1973 and McALPINE, 1981, is resumed by DEMPEWOLF, 2004:

Head

Agromyzidae family belongs to the highly diverse dipteran group Cyclorrhapha that is well characterized by the presence of the ptilinum just above the antennae. It is a sac-like organ which is inflated at the beginning of the adult life to facilitate tearing the puparium in order to escape from it. The surface of the ptilinum can be covered with scales or denticles in a variety of sizes. In matured adults only the ptilinal fissure is visible, marking the area where the ptilinum had been everted. This area is called lunule.

The figure 5-3 indicates the main head morphologycal parts. The frons can be subdivided into two structural different areas: The frontal vitta above the ptilinal fissure is weakly sclerotized, bristles and hairs are lacking. In mining flies, heavier sclerotization in the frontal area is restricted to the ocellar triangle, the frontorbital plates (frontorbits) next to the eyes and the dorsal part of the head called the vertex. These parts have often an other colour and surface structure than the frontal vitta. The size, direction and presence of some bristles and hairs located on these sclerites might be of diagnostic importance.

The number of frontorbital bristles usually ranges from 3-5 on each side. The lower frontorbital bristles are normally more or less inwards directed (medioclinate). The number of clearly medioclinate bristles can be employed for identification. The frontorbital setulae are minute, sometimes not easy to find. They can be either erect, directed to the occiput (reclinate) or to the antennae (proclinate). In some cases they can be missing. The vertical bristles are constant in position and appearance but the colour of the cuticle surrounding their base is frequently used as diagnostic feature, especially in species groups with extensive yellow coloration. The ocellar and postocellar bristles are highly constant.

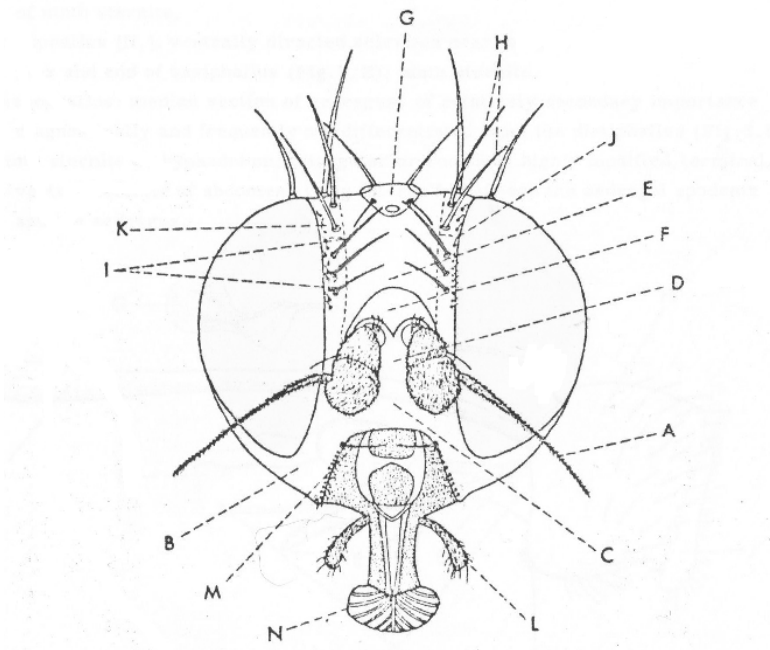


Figure 5-3. Head of Agromyza sp. in frontal view. A. arista; B. jowl; C. face; D. facial keel; E. frons; F. lunule; G. ocellar triangle; H. upper orbital bristles (*ors*); I. lower orbital bristles (*ori*); J. orbital setulae; K. orbit; L. palp; M. vibrissa; N. proboscis (SPENCER, 1976a).

The compound eyes are usually oval shaped, often with an angular hind corner. In some *Cerodontha*, *Tropicomyia* and *Japanagromyza* the eyes can be more circular and larger. If the head surface is mainly yellow, narrow dark frame often surround the eye margins. The area below the eyes is called genae or cheek. It may differ somewhat in size or colour pattern. In *Japanagromyza* the genae are conspicuously small. The lower margin of the genae is often darkened. In the literature is often distinguished between "cheeks", a membranous area immediately below the eyes, and "jowls" the membranous area below the cheeks up to the head margin (SPENCER, 1976a).

Anteroventrally at the corner of the genae (vibrissal corner) a single pair of medioclinate bristles called the vibrissae is present in all agromyzid flies. In some male *Ophiomyia* the area can be conspicuously enlarged and broadened. In that case it is called vibrissal fasciculus.

Forming a proboscis with a wide apical labellum the mouthparts belong to the nonbiting, lapping and sucking type widespread among higher Diptera. The flies are able to ingest liquid food and liquefy dry substances (e.g. dried honeydew). As diagnostic characters the mouthparts have hardly been used except for *Ophiomyia pinguis* (Fallén, 1920) where the proboscis is extremely enlarged.

As in other cyclorrhaphan flies the apical segments of antennae are highly modified. The third antennal segment (first flagellomere) is enlarged. Inserted subapically the remaining flagellomeres are reduced to a slender, bristle-like arista. The normally rounded but sometimes angular shape of the third antennal segment can be of some taxonomical importance.

Thorax

The humeri are mostly blackish, only rarely they show yellow or whitish coloration. In lateral view, the anepisternum (mesopleuron) and the katepisternum (sternopleuron) can be diagnostic through the variation in colour-patterns. Furthermore, the scutellum can be either blackish or conspicuously yellow. Sometimes the surrounding of the scutellum can be yellowish as well. The mesonotum is mostly dark, either covered with pubescence or shining (Fig. 5-4).

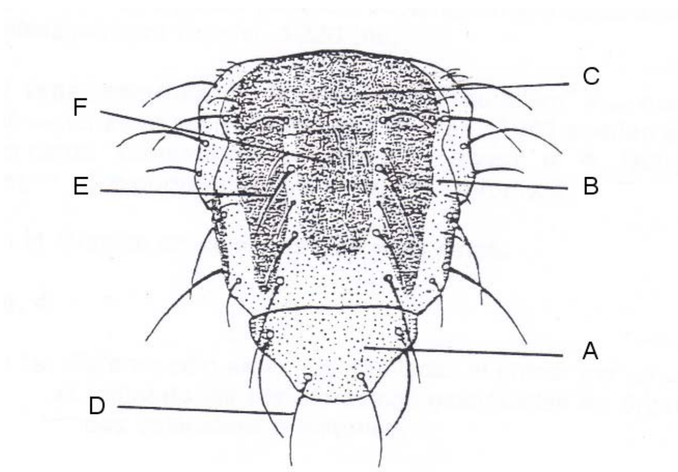


Figure 5-4. Typical Agromyzidae thorax. A, scutellum; B, scutum; C, prescutum; D, prescutellar bristles (*prsc*); E, dorsocentral bristles (*dc*); F, acrostichals bristles (*acr*) (ECHEVARRÍA, 1996).

The setae on humeri, anepisternum and katepisternum are either generally rather constant throughout the whole family or in detail variable within species. Therefore they are only rarely used as diagnostic characters.

There is more variation in the bristles on the mesonotum and scutellum. Some of the bristles and hairs shown in the drawing can be absent; especially the dorsocentral bristles at the presutural part of the mesonotum are missing in *Japanagromyza* and *Pseudonapomyza*. Furthermore the prescutellar acrostichal setulae (or simply “prescutellar bristles”) can be enlarged or as small as the neighbouring acrostichal setulae. One pair of the scutellar bristles is missing in the subgenus *Cerodontha*. The density of acrostichal setulae (or simply “acrostichals”) can vary considerably among species.

The legs are of limited significance in agromyzid taxonomy. They show some colour variation, sometimes even within species. On the fore and middle tibia sometimes one or more outstanding median spinules can be distinguished from the small hairs the legs are covered with. Those species show a stridulation mechanism (von-TSCHIRNHAUS, 1972) and bear a stridulatory scraper on the hind femora. This is a sharp long edge situated at the inner side.

Except in a few species in tropical rain forests (von-TSCHIRNHAUS, 1991) the wings are hyaline and translucent, never infuscate. Some conspicuous tracheae that are called "veins" run through each wing. The position of the wing veins and the spaces embraced by veins, which are called "cells", are of fundamental value for identification of especially higher taxa.

The most widespread modifications of wings respect other Diptera are the reduction or basal shift of the two cross veins (mainly *Phytomyza* and related taxa), the reduction of the length of the costa and "costalization".

Near the wing base the following structures might be of some significance for identification of agromyzids: the tegula at the base of the costa that have lateral hairs of varying colour, the colour of the margin and the marginal hairs of the basal lobe of the wing (squama).

The halteres can be interpreted as atrophied second pair of wings although they have got an important sensual function. Operating as pendula during flight, they serve as sensual organ. By the position of the oscillating halteres, the fly can detect and control wanted and unwanted rotation movements of the body. The coloration of the halteres (white or at least partly darkened) can be of importance for identification of agromyzid subgroups.

Abdomen

The abdomen consists of 5 pregenital segments in male and 6 in female. The first one is rather short and closely associated with the second tergite. It is only recognizable through an incomplete suture (adventitious suture).

The abdominal tergites are usually dark, brown to black, sometimes with metallic coloration. Both the joints and the margins of the tergites can be yellowish or white. Several species have got some yellow patches at the lateral sides of the tergites. As diagnostic character this coloration can be misleading because it often depends on the condition of the specimen. The joints between the tergites are usually better visible in pregnant females and in specimens stored in alcohol. In dry specimens the joints are normally inflated and therefore concealed.

The tergites are covered with fine hairs (setulae) of different size. At the posterior margins the hairs are often longer than elsewhere. Especially in females the posterior hairs of the last two tergites can be conspicuously elongated.

Stridulation mechanisms in Agromyzidae were discovered by von-TSCHIRNHAUS (1972) consisting of a file at the first abdominal segment and a scraper at the hind femora. The stridulatory file is a field of scales or small spines that produce sound when it the scraper rubs it. Although the sound itself is still not unambiguously confirmed there is little doubt about that function because similar structures have been observed in other insects. The stridulation mechanism evolved at least two times in Agromyzidae. It is present in *Agromyza*, most *Liriomyza* and some *Cerodontha* species. In *Agromyza* the stridulation file can be found in both sexes at the lateral margins of the first tergite. The stridulation organ of *Liriomyza* and *Cerodontha* shows some structural differences to that of *Agromyza* indicating an independent evolutionary history. It occurs only in males and the stridulation file is situated on the connecting membrane between tergite and sternite. The relationships between the very similar stridulation mechanisms of *Liriomyza* and *Cerodontha* are not yet fully understood.

5.1.2 Male genitalia

The current systematic diagnosis of the Agromyzidae family focuses on the study of the male genitalia to be unique for each species. Their study was initiated in the mid-twentieth century by authors such as FRICK (1952), SASAKAWA (1961), and SPENCER (1961).

The genitalia structure of the male allows us to discriminate between species and clarify the relationship between the position of the genera. Only in rare species can be identified easily from the differences in external morphology.

The most significant and stable structure in the male genitalia is the distal end of the aedeagus (distiphallus) (Fig. 5-5). Illustrations of this in side view and in either ventral or dorsal view will be invariably suffice for completely reliable identification of a species. Other structures which can be of significance are the ninth sternite, which can be elongated, conspicuously broad and rounded or narrow, the ejaculatory apodeme in which the blade can be minute or greatly enlarged as in *Amauromyza* species and finally the surstyli which may have a characteristic arrangement of bristles along the inner margin (SPENCER, 1973).

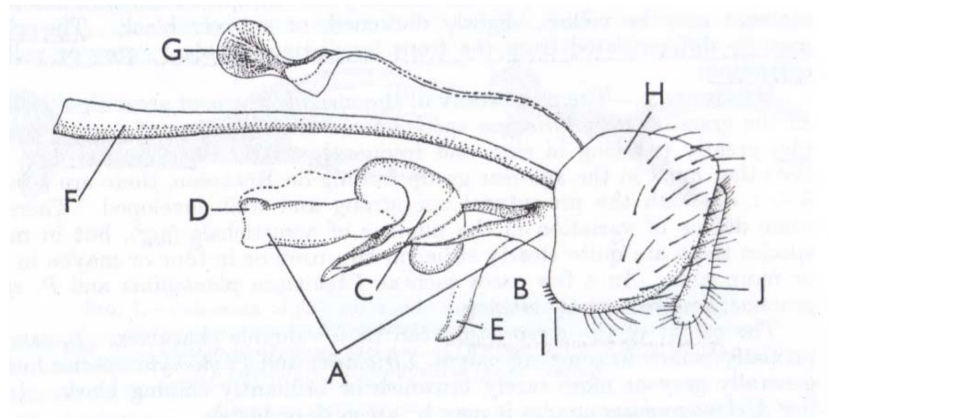


Figure 5-5. Male genitalia of typical Agromyzidae. A, aedeagus; B, basiphallus; C, mesophallus; D, distiphallus; E, hypophallus; F, aedeagal apodeme; G, ejaculatory apodeme; H, epandrium; I, surstylus; and J, cercus (SPENCER, 1972b).

The three-dimensional character of the genitalia makes it preferable a design or a picture, to its morphological description. The great diversity of forms makes it impossible to characterize an genitalia by description.

5.1.3 Female genitalia

Female genitalia is not usually used in identifying Agromyzidae. Only in cases of the absence of the male, can be included. The most significant cites in the study of the female genitalia into Agromyzidae are: IPE, 1966; PAKALNISKIS, 1996; ROMERO *et al.*, 1991; SARAY, 1986; SASAKAWA, 1958; SASAKAWA, 1961; SCHLECHTENDAL, 1901; SHIAO & WU, 2000 and ZLOBIN, 2005.

The female genitalia is characterized by being able to rip the plant tissue for oviposition and for feeding. It is characterized because the anterior part of the seventh segment form an oviscapt that can be retracted into the abdomen. The difficulty of identifying characteristics of species and the difficulty of extracting the genitalia make that its study is very little advanced. However, future studies might provide us important discrimination characters among some species.

DEMPEWOLF (2004) summarizes some diagnostic characters in current use and relevant importance. The posterior parts of the 7th segment (behind the oviscapt) form an eversible ovipositor sheath with on its surface strong sclerotized denticles of varying size. In retracted position the denticles are on the inner side. For oviposition the shaft is gradually everted. During oviposition, the denticles serve as rasping tools to facilitate boring into the plant tissue (HENDEL, 1931, 1932, 1936; SPENCER, 1987).

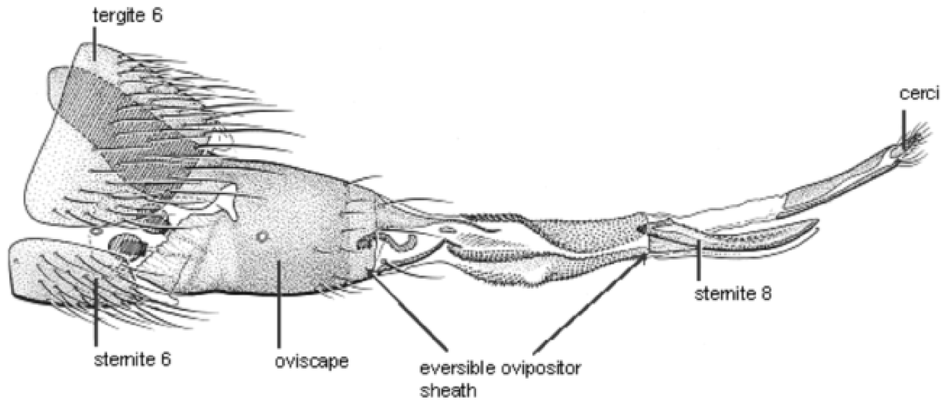


Figure 5-6. Agromyzidae female terminalia (SPENCER, 1987).

The terminal part of the ovipositor consists of a pair of egg guides (sternite 8) and the well-developed proctiger including the cerci. In contrast to the Tephritidae and Fergusoninidae, the 8th segment is not modified in a heavily sclerotized piercing device. The cerci are not coalesced with the tip of the 8th segment (SPENCER, 1987).

5.1.4 Immature stages

The most relevant studies about the morphology of the larval state of Agromyzidae are: BED, 1971a, 1971b, 1971c; BERI, 1971a, 1971b, 1971c, 1971d, 1973, 1984; De MEIJERE, 1925; DIMETRY, 1971; FERRAR, 1987; GANGRADE, 1962; OTA & NISHIDA, 1966; SINGH, 1968; SINGH & BERI, 1971, 1973; SINGH & BED, 1972; SMITH, 1989 and VALLADARES, 1992. The most recent work was carried out by DEMPEWOLF (2001) for constituting his doctoral thesis.

The study of larval stage like identification resource is a very interesting tool to allow in many cases their early identification.

The larval state does not contribute too many diagnostic characters, and generally it must resort to electron microscopy for proper observation. This does not usually used as a tool for identification of most species. However, recent advances in molecular biology studies could allow the early genetic identification (e.g. CHIU *et al.*, 2000; MASETTI *et al.*, 2006 and SCHEFFER *et al.*, 2007). The achievement of establishing the Agromyzidae molecular basis for all known species may in future allow a rapid detection and diminish important economic losses in crops and can increase the list of host-plants.

The larval state of Agromyzidae is characterized like in other flies belonging to the suborder Cyclorrapha, for lacking legs and having movements of contraction and elongation for its displacement. The main characteristic is that this miners are exclusive to plants. They usually have white (almost translucent) colour and a size ranging from few millimeters to 2 cm in species of the genus *Phytobia*. In the case of being parasited the colour tends to be of brown to black due to the internal development of the parasite.

The mandibles are connected with some internal sclerites that constitute the cephalo-pharyngeal skeleton (TESKEY, 1981 and COURTNEY *et al.*, 2000). Both structures provide an immediate information of the subfamily, but not enough to separate close genera (SPENCER, 1972b).

An excellent diagnostic feature to distinguish agromyzids from other plant inhabiting maggots is the reduction or absence of the dorsal bridge of the cephalo-pharyngeal skeleton in Agromyzidae (Fig. 5-7). In non-agromyzid dipteran leaf miners and in other Diptera the dorsal bridge is usually large and prominent. Furthermore, the shape of the mandibular complex of Agromyzidae and other Diptera is distinctive. The latter normally have got well developed abductor apodemes, whereas agromyzids do not possess these structures. In leaf-mining Agromyzidae the mandibular complex is normally higher than long. Another visible character in most agromyzid larvae lies in the dorsal arm of the basal part of the cephalo-pharyngeal skeleton. It seems to be divided into two different parts due to the development of a window within the basal part. However, since the lower part frequently is reduced or hardly visible, the character is of limited use for recognition of the family Agromyzidae (DEMPEWOLF, 2004).

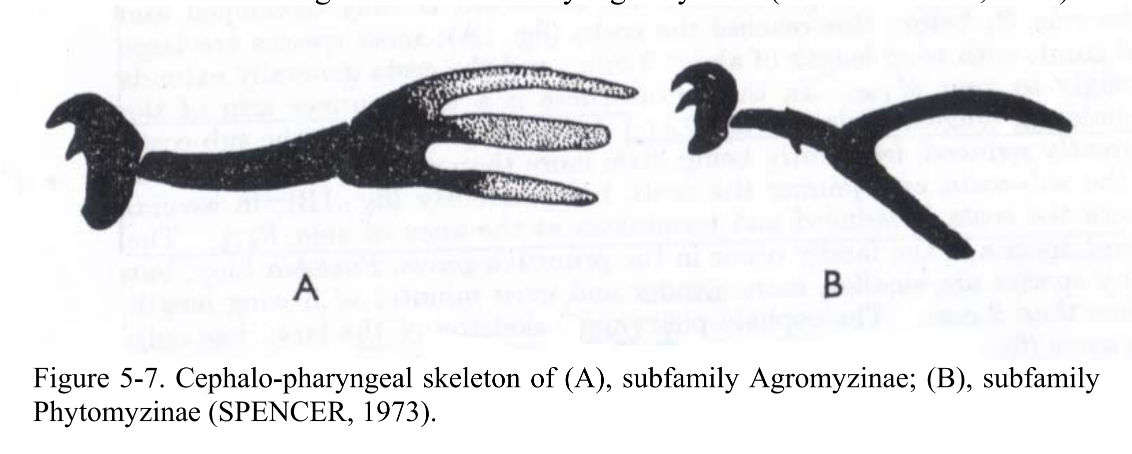


Figure 5-7. Cephalo-pharyngeal skeleton of (A), subfamily Agromyzinae; (B), subfamily Phytomyzinae (SPENCER, 1973).

The mouth-hooks consist of a rigid, paired structure, with two halves normally arranged asymmetrically, so that in lateral view the mouth-hooks appear to alternate. There is a little specific variation in the mouth-hooks and many species can be reliably separated on this character. Both the anterior and posterior spiracles provide valuable diagnostic characters but the latter show greater differentiation. The spiracular processes may lie on the surface of the anal segment on scarcely defined plates or may be raised on conspicuous and characteristic stalks or protuberances. In the primitive arrangement there are three spiracular openings or bulbs on each process but very commonly these may proliferate up to 10, 15, 20, 30 or even more (SPENCER, 1972b).

The basic characters of the larvae are manifested in the puparium, although it is very difficult and sometimes impossible, to carry out the count of the spiracular bulbs number. Joined to the first segment of the puparium appears adhered the mouth-hooks and the cephalo-pharyngeal skeleton.

Other diagnostic characters that can be used for identification is the colour of the puparium which may be white, grey, brown, orange, dull or shining black. The form can also vary from cylindrical to flattened.

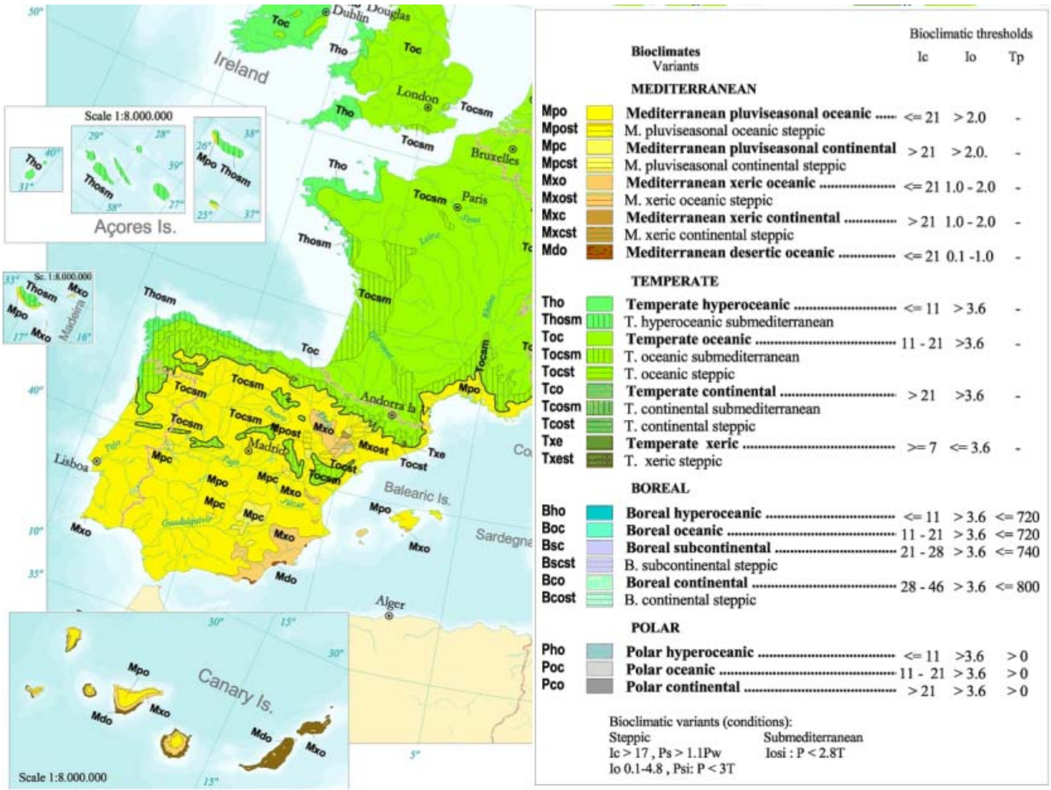
5.2 Methodology

5.2.1 Origin of the material studied

The systematic study of biodiversity presented in this thesis was carried out in three protected areas in the Community of Valencia which are currently declared as Natural Parks: Tinença of Benifassà (Castellon), "Font Roja" (Alicante) and "Lagunas de La Mata- Torrevieja" (Alicante) (Fig. 5-8).

Figure 5-8. Location of the areas studied into Community of Valencia (Source: *http://earth.google.es/*).

According to the bioclimatic and termoclimatic classification established by RIVAS-MARTINEZ (2004) (Fig. 5-9) the Natural Parks of "Font Roja" and "Lagunas de La Mata-Torrevieja" are framed within the "Mediterranean xeric oceanic" and "Inframediterranean", respectively. In this way, the maximum annual average temperatures are less than or equal to 21 º C and maximum annual rainfall is between 450-580 l/m^2. The Natural Park of Tinença of Benifassà differs from previous ones to be framed within the "Mediterranean publiseasonal oceanic" termoclimate registering below average temperatures and higher precipitation in respect of the two cited above.



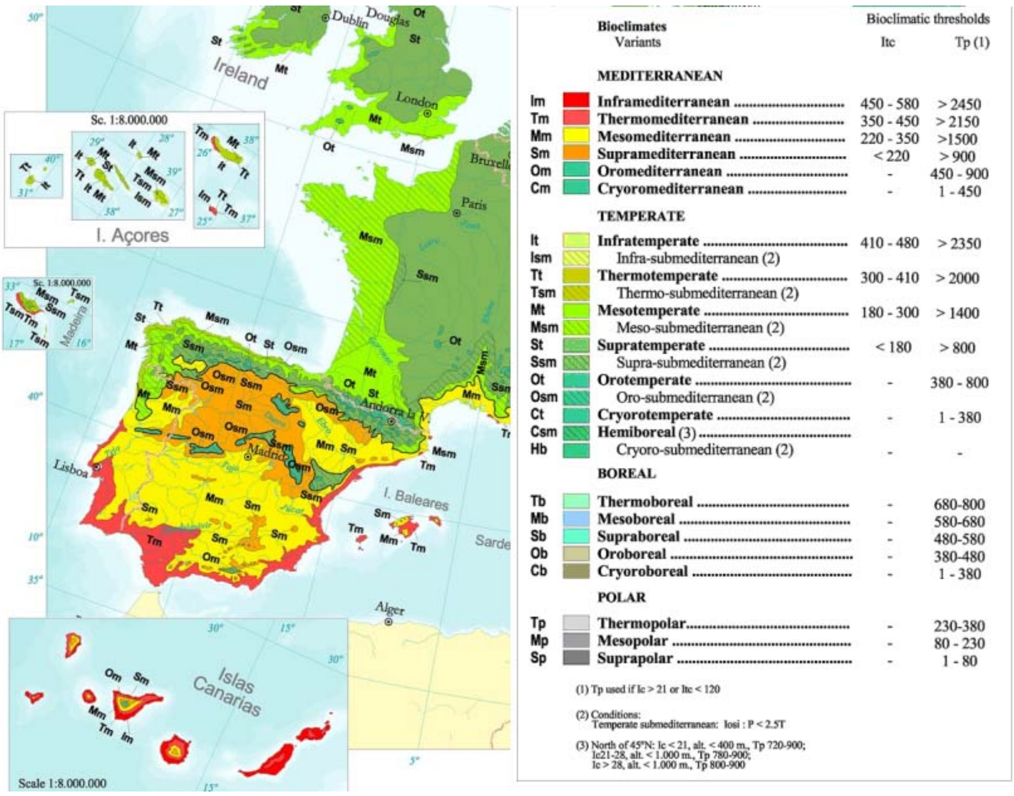


Figure 5-9. Southwestern Europe. Top: bioclimatic map. Bottom: termoclimatic map (RIVAS-MARTINEZ, 2004).

5.2.1.1 "Tinença de Benifassà" Natural Park

5.2.1.1.1 Location

The Tinença of Benifassà is located in the north of the Community of Valencia bordering the provinces of Teruel (west) and Tarragona (north). The Natural Park of the "Tinença de Benifassà" was declared on May 19th, 2006 by decree 70/2006 of the Council. It covers some 5000 Ha, affecting nearly 26000 hectares with its Natural Resources Organization Plan (PORN in spanish, it's not a joke). It is extended from the historic district of the same name to the term of Vallibona. In this territory are the rivers of Sénia and Servol (also called River "Les Corses") that cross the last buttress of the Iberian system. It includes the villages of the Pobla de Benifassà, Coratxà, El Boixar, Fredes, El Ballestar, Bel (Rossell), Vallibona and Castell de Cabres (Fig. 5-10).

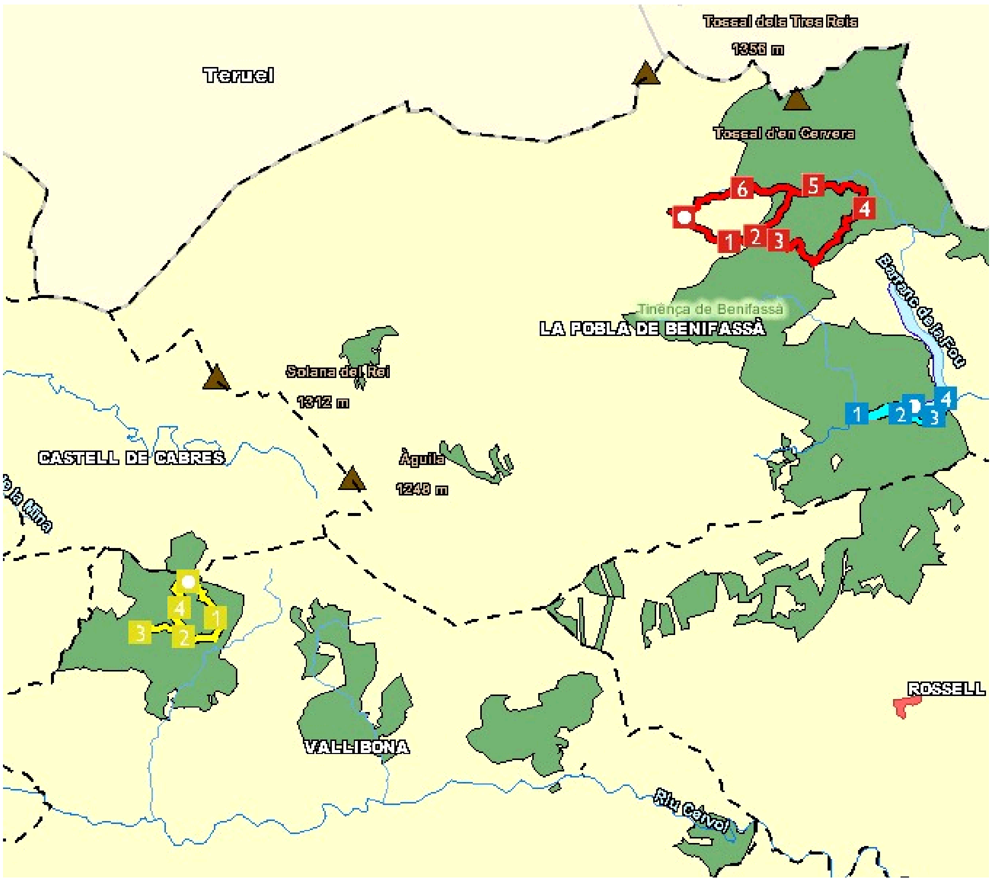


Figure 5-10. Map location of the "Tinença de Benifassà" Natural Park (Source: *http://www.cma.gva.es*).

The vegetation of the park is well represented by forests of pine, holm oak woodlands, oak and riparian forests. These courses are specially protected and represented in the thirteen microreserves of flora found in the PORN area giving special protection to threatened or endemic species.

Besides the protection offered by the figures of Natural Park and Flora microreserve, the Tinença of Benifassà is protected because it is a Site of Community Interest (SCI) and also for being a Special Protection Area for birds (SPAs).

5.2.1.1.2 Climatology

Its climate is continental humid with annual average temperatures below 12ºC, with frosts during most of the year and with rainfalls represented by annual mean precipitation that varies with the topography of the different zones, between 600 and 1000 l/m2 (Fig. 5-11). It is framed into the supramediterranean bioclimate.

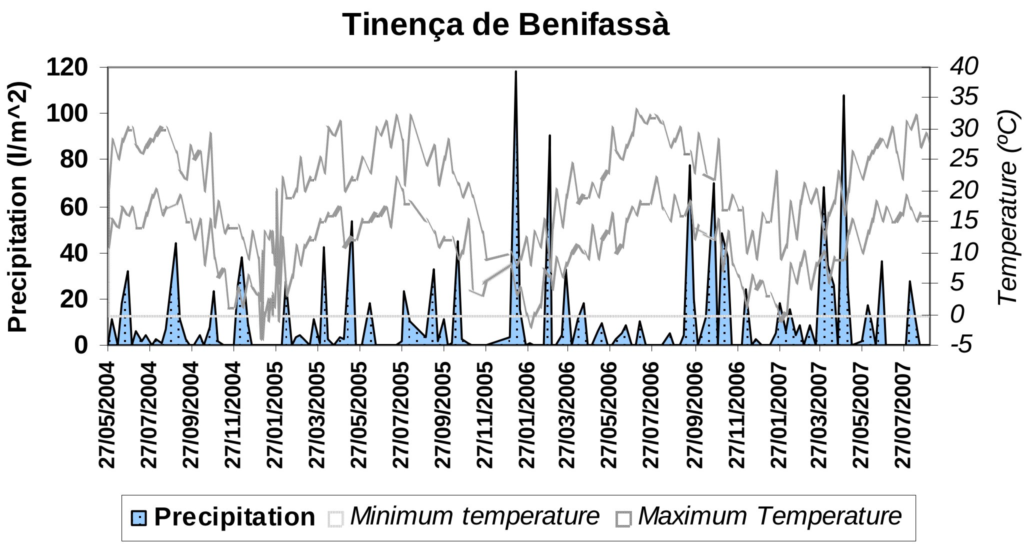


Figure 5-11. Trends of maximum/minimum temperatures and precipitation during the years 2004-2007 representative of the "Tinença de Benifassà" Natural Park.

5.2.1.1.3 Vegetation

The studied areas are principally in 2 of the 13 microreserves established in the PORN of the Natural Park, the "Tossal Cervera" and "Bolavar de Castell de Cabres".

Tossal de Cervera: located with in the provincial limit of Tarragona is formed by pine forests of mixed black and albar pine with boxwood, limestone crags and shady perennial grasslands rich in orchids. In them we find populations of the predominant species such as *Arenaria conimbricensis* Brot., *Euphorbia amygdaloides* L., *Hieracium laniferum* Cav., *Paeonia officinalis* L., *Pyrola chlorantha* Sw. and *Valeriana tripteris* L.

Bovalar de Castell de Cabres: located close to the village consists of oak forests and perennials grasslands composed of orchids as *Listera ovata* (L.) R. Br., *Phyteuma orbiculare* L., *Platanthera chlorantha* (Custer) Rchb. and *Quercus faginea* Lam.

In the "Tinença de Benifassà" Natural Park the diversity of environments is very large, and it is possible to find a wide variety of habitats. Different biotopes of European interest within seven main types are observed: freshwater habitats, temperate heathlands and shrublands, sclerophyllous scrub, herbaceous formations, bogs, forests and rocky habitats.

The predominant habitats within the studied areas are:

Heaths with aliaga: these shrubs form a bush band above the forest levels or live in degraded areas and clear forests. They have high variability and are often floristically rich in endemic plants. It is predominated by the the presence of dominant species such as *Anthyllis erinacea* Link., *Erica multiflora* L. and *Ulex parviflorus* Pourret.

Box on rock slopes: boxwood (*Buxus sempervirens* L.) is accompanied by dense scrub and forest species or species of *Amelanchier ovalis* Medik., *Berberis*, *Rosa*, etc.

Arborescent matorral with *Juniperus*: these open formations are characterized by the presence of *Juniperus communis* Lam., *Juniperus oxycedrus* L. and *Juniperus phoenica* L. In this habitat, the spaces between individuals of *Juniperus* are occupied by low bushes or grass, depending on altitude and orientation.

Mediterranean scrub and pre-steppe: varied scrub with *Anthyllis cytisoides* L., *Asparagus* sp., fan palm (*Chamaerops humilis* L.), *Euphorbia* sp., *Lavandula* sp., *Pistacia lentiscus* L., *Thymus* sp., etc. are present.

Rocky grassland: it is composed of grassland on rocky surfaces and other similar emerging rocky soils, growing on alkaline substrates and at different altitudes. They are communities with an open structure composed of a top layer of fleshy-leaved plants (gross) with *Sedum sediforme* (Jacq.) Pau and under a diverse set of ephemeral annual plants that take advantage of the seasonal rainfall, by rapidly developing their life cycle before the drought of summer.

Alpine meadows and subalpine limestone: these are high mountain meadows in developed areas and clear understory of coniferous forests of high mountains. Presents a significant variability with an abundance of endemic flora. In any case, they are common weeds of *Festuca* and *Poa* genera accompanied by clumps of woody *Arenaria* sp., *Helianthemum* sp., *Paronichia* sp., *Teucrium* sp. and *Thymus* sp.

Dry grasslands and scrub rich in orchids: these dense formations are very rich in species which can reach half a meter tall. The dominant species are grasses such as *Brachypodium retusum* (Pers.) Beauv., *Bromus erectus* Huds., *Festuca nigrescens* Lam. or *Helictotrichon cantabricum* (Lag.) Gervais. Sometimes, these fields contain good populations of various genera of orchids, particularly in *Ophrys*, *Orchis*, *Dactylorhiza*, and so on.

Areas of sub-steppe annual herbs: they are always well-lit environments in clearings among bushes or rock ledges. Annual herbaceous plants are often of ephemeral spring development. They have high variability in abundance of endemic Mediterranean flora including *Arenaria* sp., *Chaenorrhinum* sp., *Linaria* sp., *Silene* sp., etc.

Mediterranean wet grass: they are dense meadows, green all year, notably stressing the rushes (e.g. *Carex mairii* Coss. & Germ., *Juncus acutus* (L.) Torr. ex Retz. and *Scirpoides holoschoenus* (L.) Sójak) forming a discontinuous upper stratum. In the lower layer are common grasses such as *Agrostis* sp., *Briza minor* L., *Cynodon dactylon* (L.) Pers., *Melica ciliata* L., *Festuca* sp. and *Poa* sp.

Meadow grass of plains and from the mountain to alpine floors: it is formed by bleak communities that are found in areas of high moisture and organic matter. These formations are composed of herbaceous plants noted as *Aconitum vulparia* Rchb., *Alliaria petiolata* (Bieb.) Cavara & Grande, *Filipendula vulgaris* Hill ex Moench. and *Urtica dioica* L.

Scree: stone accumulations of mountain slopes with scattered vegetation that roots between rock fragments. Among the most common genera of plants found are *Biscutella, Crepis, Iberis*, *Linaria*, *Viola*, *Scrophularia*, and so on. The genetic isolation imposed by the restrictive conditions and the geographical distance of the plant populations determines a presence of a high level of endemicity.

Rock vegetation: plant communities of open-rooted perennial plants in cracks and crevices. These are poor communities of many different species and with a broad geographical scale because of their variability. We found species of the genus *Androsace*, *Antirrhinum*, *Centaurea, Linaria, Petrocoptis, Saxifraga, Sedum*, *Silene* or *Teucrium*. Also as *Asplenium* ferns, *Ceterach* or *Cosentinia*.

Slope forests, screes and ravines: mixed deciduous forests of steep and shady places. These are different formations mixed with maples (*Acer granatense* Boiss.) linden (*Tilia platyphyllos* Scop.) and checkerberry (*Sorbus aria* (L.) Crantz). To rich arboreal stratum accompanies many shrubs, such as *Arbutus unedo* L. and *Juniperus phoenicea* L.

Perennial forests: these forests are composed of *Quercus ilex* L. with shrubs such as *Arbutus unedo* L., *Juniperus communis* L., *Smilax aspera* L., *Rubia peregrina* L., and so on.

Formations of Mediterranean endemic black pine: the black pine (*Pinus nigra* Arn. subsp. *salzmannii*) is the Western variant of endemic *Pinus nigra* Arn., a species widely distributed in the Mediterranean area. It is found above 900 m creating open formations mixed with *Pinus sylvestris* L., and a shrub mantle composed of *Amelanchier ovalis* Medik., *Erinacea anthyllis* Link., *Helleborus foetidus* L., *Juniperus communis* L., *Sorbus aria* (L.) Krantz, etc.

Mediterranean pine: pine forests of *Pinus halepensis* Mill. that act like pioneers in the succession towards forests of *Quercus*. It appears at low altitude, typically under 800 m. It forms masses of mixed *Juniperus oxycedrus* Sibth. & Sm., *Phillyrea angustifolia* L., *Quercus coccifera* L. and *Rosmarinus officinalis* L.

5.2.1.2 "Font Roja" Natural Park

5.2.1.2.1 Location

The Natural Park of “Font Roja” is located in the north of the province of Alicante. It extends from east to west between the towns of Alcoy (northeast) and Ibi (southwest) in the region of l'Alcoià (Fig. 5-12).

The natural protected area covers 2298 Ha. and was declared a Natural Park on April 13th, 1987, by Decree 49/1987 of the Council of the Generalitat Valenciana. It has also been included along with the Sierra de Mariola, like as Special Protection Area for Birds (SPAs) and Sites of Community Interest (SCI).

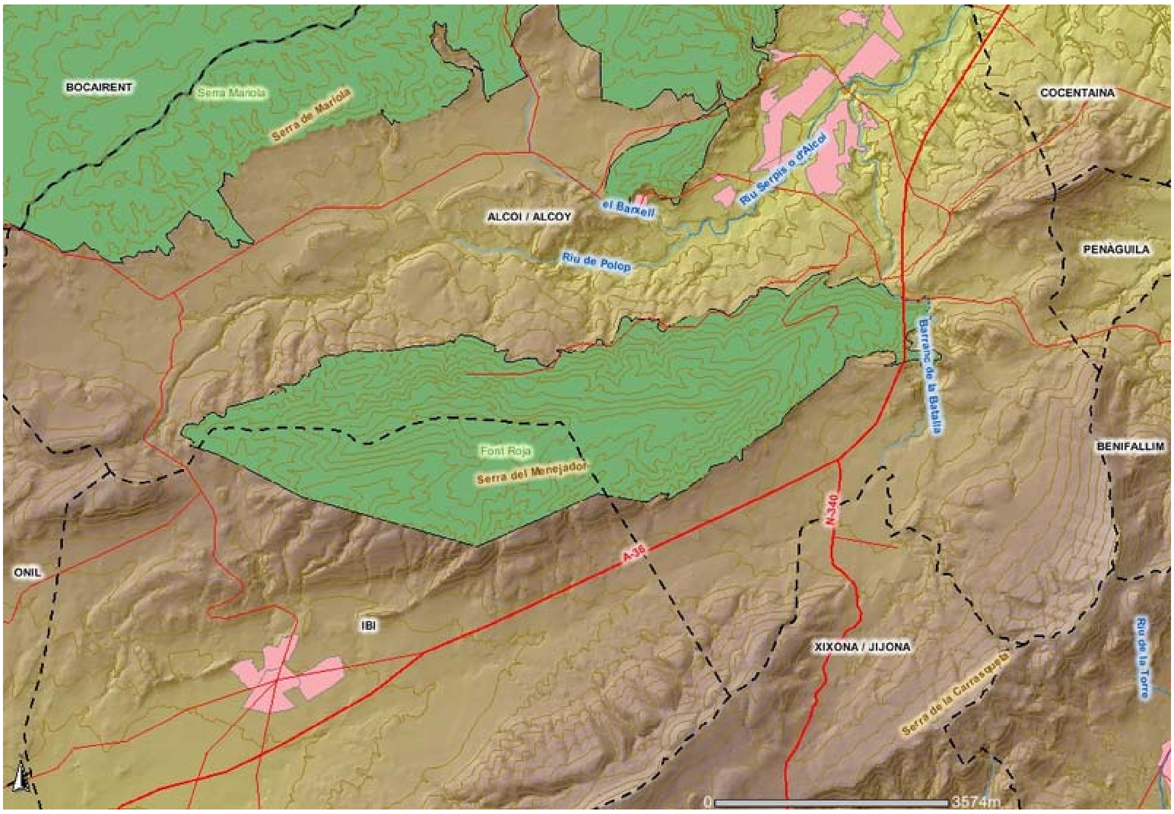


Figure 5-12. Map location of the “Font Roja” Natural Park (Source: *http://www.cma.gva.es*).

This site is a good representation of mixed Mediterranean forest. It is a mountainous elevation oriented from southwest to northeast. This situation sets a clear difference for the distribution of vegetation on both sides, the shade and the sunshine, giving the area a high ecological and landscape. Its highest points are the Menejador summit (1356 m) and Teixereta (1339 m).

The north face of the Sierra highlights the presence of high embankments whose bases are arranged in quarries. The slope is higher in the north in respect to the south, where the relief is smoother.

The mountains are drained by numerous ravines which usually do not carry water. The ravines of the northern slopes drain into the “Polop” river, later renamed “Barxell”. It joins with the “El Molinar” river and then the “Serpis” river rises that flows in Gandía. The ravines of the southern slope are considered tributaries of the “Verde” river, “Montnegre” or “Seco” which flows in “El Campello” (Alicante).

The mountains orientations, spread out from the northeast to southwest, it causes cold and damp winds dominant in the park, they are retained in the north facing areas and the water contained flows down.

This fact, together with the relief rather steep and rugged in the north, and the predominance of limestone materials in the lithological composition, have caused the presence of different vegetation units.

5.2.1.2.2 Climatology

The climatology of the “Font Roja” Natural Park is characterized by the east-west orientation of the mountain range means clouds carried by the humid winds from the northwest are retained on the northern slope and then the precipitations come down in this place. Thus, a screen effect on the southern slope is produced, an effect that is manifested by the differences in annual rainfall between Ibi (402 mm) and Alcoy (479 mm) despite the greater topographic elevation of the Ibi station. The same effect occurs with abundant low clouds and fog during autumn and winter, which contribute significantly to the total annual precipitation.

Climatic differences between north and south slopes are accentuated by the lowest insolation received by the shady side due to the orientation of the mountain ranges and the high incline.

Based on the data available in the state agency of meteorology (EAM in spanish, no joke) they were chosen as representative data of the study of temperatures and precipitation registered at the Bocairent station, whose oreography is very similar and which thermometric data present very few differences with those recorded historically in the “Font Roja” Natural Park. The Figure 5-13 shows the temperature (°C) and precipitation (l/m^2) registered during 2004-07.

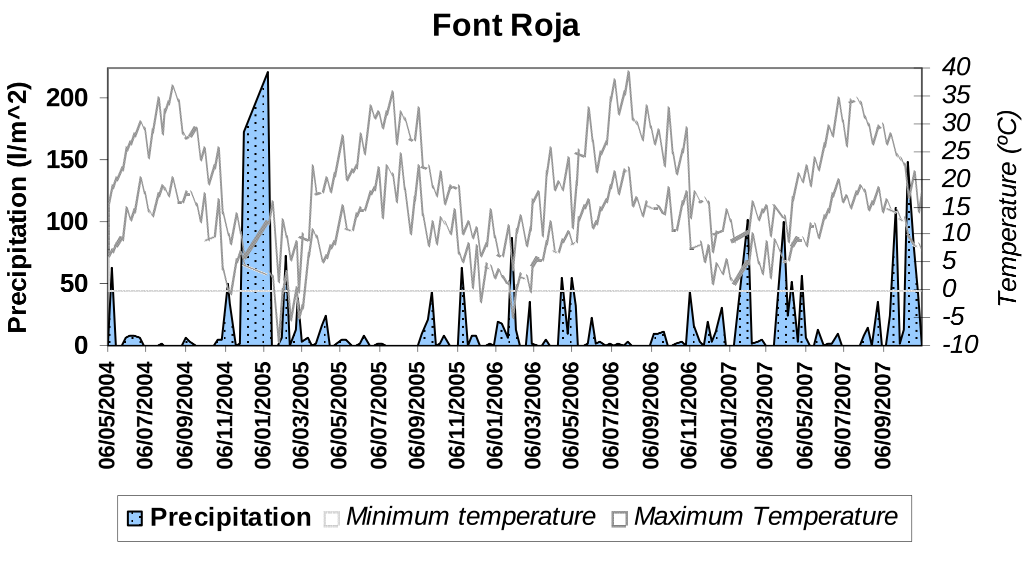


Figure 5-13. Trends of maximum/minimum temperatures and precipitation during the years 2004-07 representative of the “Font Roja” Natural Park.

As regards the distribution of rainfall throughout the year, it appears that the highest rainfall occurs in the winter months, with lower rainfall intensity in spring. The highest rainfall was recorded in December with precipitations around 250 l/m^2. It was found that rains registered during previous years coincide with a semiarid climatic and ombroclimatic zone. The drier summer months are between July and September.

Two decades ago, the presence of different climate floors could be distinguished in the Natural Park studied, considering the north side with upper subhumid ombroclima (annual rainfall between 600-1000 mm) and the south face with dry ombroclimate (annual rainfall between 350-600 mm). Currently the high average temperatures registered throughout the year (15-20 ºC) and the low rains mean the predominant ombroclimate is dry and thermomediterranean.

5.2.1.2.3 Vegetation

The "Font Roja" Natural Park is characterized by having a typical Mediterranean vegetation, but due to its special topography can be distinguished by different vegetation types and endemic plants.

BORONAT *et al.* (1989) following the classification criteria of RIVAS GODAY *et al.* (1959), BOLÒS (1967) and COSTA (1986), five distinct sets of trees which form the vegetation of each bioclimatic floor are distinguished:

<u>Deciduous forest (Wetter Supramediterranean Floor)</u>. In the shadowy and moist corners of the north face and above 1250 m., deciduous forests mainly composed of oak (*Quercus faginea* Lam.), ash (*Fraxinus ornus* L.), maple (*Acer granatense* Boiss.), the checkerberry (*Sorbus aria* (L.) Crantz) and yew (*Taxus bacatta* L.) were arranged. The shrub and herbaceous layer emphasizes the presence of *Amelanchier ovalis* Medik., *Cytisus patens* Murr., *Iberis prutii* Tin., *Lathyrus elegans* Porta & Rigo and *Viburnum tinus* L., among others. Biogenetic interest from plants that make up in this forest and some exclusive presence in the area of Valencia give this place a high conservation character value.

<u>Shady holm oak (Supramediterranean floor with subhumid Ombroclimate)</u>. Between 600 and 1250 meters above sea level the holm forests (*Quercus ilex* L. subsp. *rotundifolia*) are located, which are enriched with deciduous plants such as ash or maple, and oak (*Quercus faginea* Lam.) in cool and shady areas. In the understory of the holm oak high diversity and number of species abound such as ivy (*Hedera helix* L.), honeysuckle (*Lonicera implexa* Ait.), the blonde (*Rubia peregrina* L.), or durillo (*Viburnum tinus* L.).

<u>Sunny brushes (Dry Supramediterranean Floor)</u>. This is a scrub with scattered holm, due to higher insolation and drought. Species that commonly appear in this unit are: the cushion of a nun (*Erinacea Anthyllis* Link) on 900 meters above sea level, Mariola sage (*Salvia blancoana* Webb & Heldr.), aliaga (*Ulex parviflorus* Pourr.), thyme (*Thymus vulgaris* L.) and pebrella (*Thymus piperella* L.).

<u>Rupicolous vegetation (Dry Mediterranean Floor)</u>. The typical tree is the holm oak (*Quercus ilex* L.). On the shady side slopes of the "Menejador" are frequent plants

adapted to grow in conditions of scarcity of soil, such as *Jasione foliosa* Cav., the *Potentilla caulescens* L., etc. Different rooting strategies allow them to settle in the cracks that accumulate small amounts of soil.

Runar vegetation (Dry Supramediterranean Floor). Located on the south side of the mountains, characterized by the existence of a shortage of soil and high evaporation, holm oak vegetation dominate. On the slopes covered with loose stones at the base of the abrupt, grow plants adapted to live in unstable environments like guillomo (*Amelanchier ovalis* Medik.), ash, maple and checkerberry.

In the lower elevations of the mountains, in areas where the charcoal and holm oak logging are intense, the land area has suffered a severe degradation. The pine forests currently present are the result of a large reforestation carried out on older holm oak forests. In general, the areas assigned to crops have little relevance because of the unfavourable weather and geographical conditions. At present the crops are basically cereals, fruits and olives.

5.2.1.3 "Lagunas de La Mata-Torrevieja" Natural Park

5.2.1.3.1 Location

This area, of 3743 hectares, was declared a nature reserve by the Valencian government in January 27th, 1989 located in the district of Vega Baja del Segura (south of Alicante province).

The "Lagunas de La Mata-Torrevieja" is in the district of Vega Baja del Segura, occupying part of the towns of Guardamar del Segura, Torrevieja, Los Montesinos and Rojales. It shapes alongside "El Hondo" and the "Salinas de Santa Pola", a wetland triangle with international importance in the south of Alicante (Fig. 5-14).

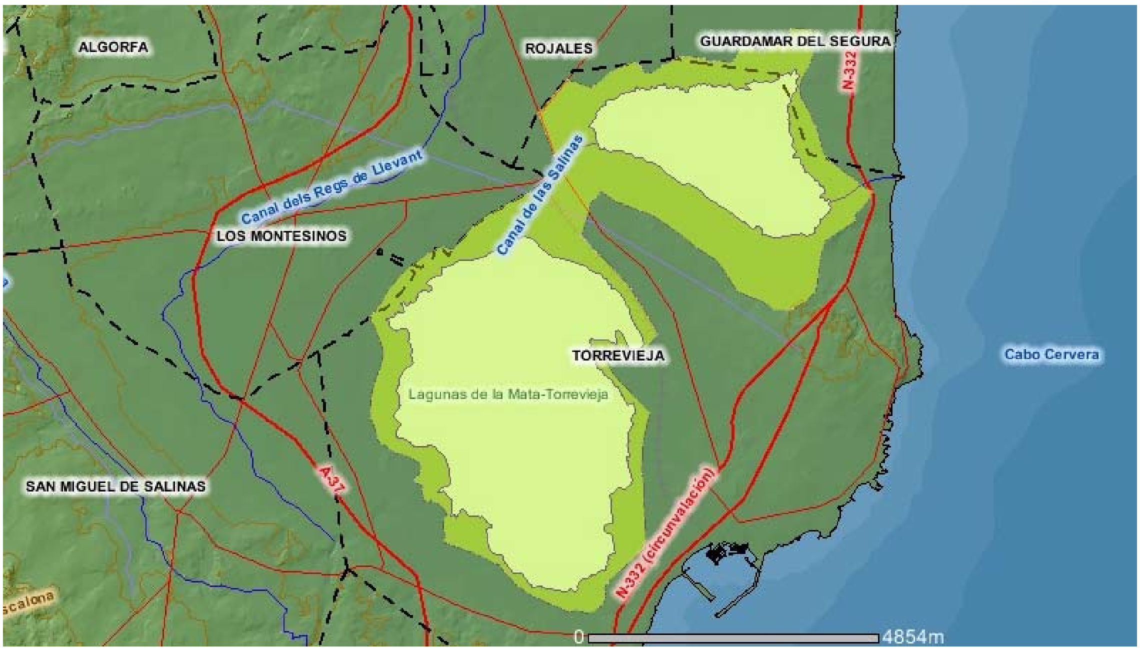


Figure 5-14. Map location of the "Lagunas de La Mata-Torrevieja" (Source: *http://www.wikipedia.org*).

The Natural Park of the "Lagunas de La Mata-Torrevieja" has an area of 3700 hectares. Of these, 2100 are beds of water, while the rest is a round (1400 hectares the lagoon of Torrevieja and 700 "La Mata").

The two lagoons are separated by an anticline called "El Chaparral". A canal linking the two depressions which are also communicated artificially with the sea by another channel known as "The Acequion", which forms an operating unit of salt. "La Mata" lagoon serves as a storage heater, while the salt is harvested in Torrevieja.

The Neocuaternaria basin, formed by the reliefs in the group of faults in the Lower Segura and "San Miguel de Salinas", are the lagoons. A series of gullies and avenues in scheme intermittent discharge their water to the basin, especially in the lagoon of Torrevieja, due to its proximity to the "San Miguel de Salinas" mountain range.

5.2.1.3.2 Climatology

It is characterized by high temperatures and a semiarid climate with annual rainfall less than 300 mm. It distinguishes different areas such as salt marsh, carrizal-juncal and scrubland. The saline ground is present a round the lagoons with high salinity. The carrizal-juncal zones are located in areas round the lagoons and present less pronounced salinity and water-logged.

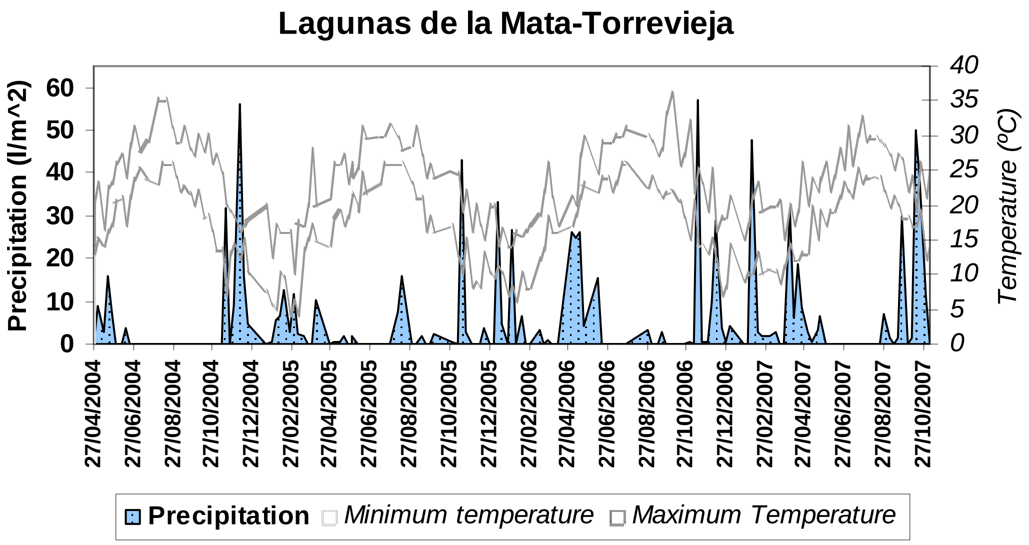


Figure 5-15. Trends of maximum/minimum temperatures and precipitation during the years 2004-07 representative of the "Lagunas de La Mata-Torrevieja" Natural Park.

The climate data used in these studies come from Torrevieja weather station (Fig. 5-15). Maximum, minimum and average annual temperatures recorded are around 22.5, 14.5 and 18.5ºC, respectively. The annual average rainfall is around 300 l/m^2 or less.

This type of weather in early May causes that the presence of high temperatures and low rainfall resulting in the disappearance of most of the fresh broad-leaved flora in the park. In June, the high daytime temperatures (>35ºC) (Fig. 5-16) mean the dominant flora basically covers grass in virtually the whole of certain areas.

Figure 5-16. Illustrated photographs showing the important development of grasses in late April.

5.2.1.3.3 Vegetation

The Arthrocnemetalia order, within which the formations of *Arthrocnemum macrostachyum* (Moric.) Moris and *Juncus subulatus* Forsk., is well represented in some zones of the Park. Also, the salt steppes of the Limonietalia order and species of *Senecio auricula* Coss. subsp. *auricula* are present in the various associations of European interest.

The wet salt marsh, formed by the Carrizal-Juncal (e.g. *Elymus farctus* (Viv.) Runemark ex Melderis, *Phragmites australis* (Cav.) Trin. ex Steud., *Piptatherum miliaceum* (L.) Coss., etc.), appears in places where there are contributions of surface water, as in the north of the lagoon of La Mata and in some isolated sections of the Torrevieja lagoon.

In the southern area of the "Lagunas de La Mata" there is also mountain vegetation basically consisting of Mediterranean coscojar (e.g. *Chamaerops humilis* L., *Quercus coccifera* L., *Rhamnus lycioides* L., etc.), Aleppo pine (*Pinus halepensis* Mill.), *Lygeum spartum* L. and *Thymus vulgaris* L.

The aquatic vegetation is almost nonexistent in this type of wetlands due to high water salinity. However, next to the lagoons one finds the best conserved areas of dry and wet salt marsh vegetation in the Community of Valencia.

5.2.2 Characterization of the habitats

Within each of the parks studied areas around 100 m^2 were selected, in which it was carried out the detection and collection of affected material by Agromyzidae miners during the years 2006-2007.

Below the sampling points studied are listed within each park with a brief description of the habitats and their vegetation.

Tinença de Benifassà

In the Natural Park of "Tinença de Benifassà" 7 points were selected mainly in 2 of the 13 PORN microreserves registered in the park, the "Tossal de Cervera" and the "Bolavar de Castell de Cabres" (Table 5-1).

Fig. 5-17. Illustrated photographs showing the topography of the "Tossal de Cervera" (left) and the "Bolavar de Castell de Cabres" (right).

Locality	Code point	GPS (38 Channels)	High
Tinença de Benifassà	TB1	N40°39'22.6"E00°09'26.8"	755
	TB2	N40°40'05.8"E00°08'25.9"	740
	TB3	N40°39'51.3"E00°08'30.0"	727
	TB4	N40°39'31.4"E00°07'46.5"	783
	TB5	N40°39'18.9"E00°09'08.9"	712
	TB6	N40°39'44.5"E00°10'58.5"	721
	TB7	N40°39'48.9"E00°10'21,4"	710

Table 5-1. Sampling points studied in the Natural Park of "Tinença de Benifassà".

TB1 habitat. (Fig. 5-18). It is located in the town of "Pobla de Benifassà" next to the urbanized area. It corresponds to an area composed of vegetable crops, stone fruit (*Prunus avium* L. and *Prunus dulcis* (Miller) D.A. Webb var. *dulcis*), pome fruit (*Pyrus communis* L., *Ficus carica* L.) and isolated specimens of *Quercus rotundifolia* Lam.

Figure 5-18. Illustrated photographs showing the orography of the habitat TB1 in "Tinença de Benifassà" park.

It is close to areas of abandoned agricultural fields that have been replaced by the typical vegetation of the site. Typical vegetation collected within this area is *Atriplex patula* L., *Carduncellus monspelliensium* All., *Chenopodium murale* L., *Diplotaxis erucoides* L., *Hyoscyamus albus* L., *Lactuca sativa* L., *Lycopersicon esculentum* Miller, *Medicago sativa* L., *Parietaria judaica* L., *Pyrus communis* L., *Silene vulgaris* (Moench) Garcke, *Sonchus oleraceous* L., *Sonchus tenerrimus* L. and *Taraxacum obovatum* (Willd.) DC.

TB2 habitat. (Fig. 5-19). Corresponds to an area included in a forest of *Quercus ilex* L. subsp. *Ilex, Pinus nigra* Arnold and *Pinus sylvestris* L., in which the shady areas are combined with clear areas where the sunlight is important. The presence of low bushes and climbing plants is typical such as *Cistus albidus* L., *Cistus clusii* Dunal, *Cistus monspeliensis* L., *Colutea arborescens* L., *Convolvulus arvensis* L., *Coriaria myrtifolia* L., *Cuscuta epithymum* (L.) L., *Juniperus phoenicea* L., *Juniperus thurifera* L., *Ononis natrix* L., *Pistacia Lentiscus* L., *Prunus spinosa* L., *Quercus coccifera* L., *Rhamnus lycioides* L., *Rubia peregrina* L., *Rubus ulmifolius* Schott, *Spartium junceum* L., *Ulex parviflorus* Pourr., and so on. Among the flora collected by detecting mines in any part of the plant is *Bupleurum fruticescens* L., *Centaurea scabiosa* L. subsp. *cephalariifolia* (Willk.) Rivas Goday & Borja, *Centaurea seridis* L., *Cytisus heterochrous* Webb ex Colmeiro, *Dactylis glomerata* L., *Medicago sativa* L., *Ononis spinosa* L. subsp. *australis* (Sirj.) Greuter & Burdet, *Lonicera etrusca* G. Santi, *Lonicera implexa* Aiton, *Knutia arvensis* (L.) Coulter, *Thymelaea tinctoria* (Pourret) Engl. and *Xeranthemum inapertum* (L.) Mill.

Figure 5-19. Illustrated photographs showing the orography of the TB2 habitat in the "Tinença de Benifassà" Natural Park.

TB3 habitat. (Fig. 5-20). It corresponds to an open area of fields of *Prunus dulcis* (Miller) D.A. Webb var. *dulcis*, which borders the typical scrub of the TB2 zone. The presence of rupicola vegetation on separation slopes of lands is current.

Among the vegetation that could be undermined by Agromyzidae are *Anagallis arvensis* L., *Argyrolobium zanonii* (Turra) P. W. Ball, *Brachypodium retusum* (Pers.) P. Beauv., *Centaurea scabiosa* L. subsp. *cephalariifolia* (Willk.) Rivas Goday & Borja, *Crepis bursifolia* L., *Cynoglossum cheirifolium* L., *Cynoglossum creticum* Mill., *Diplotaxis erucoides* L., *Lathyrus aphaca* L., *Medicago arabica* (L.) Huds, *Medicago lupulina* L., *Medicago sativa* L., *Plantago lagopus* L., *Reichardia picroides* (L.) Roth, *Sonchus tenerrimus* L., *Taraxacum obovatum* (Willd.) DC. and *Vicia sativa* L. subsp. *sativa*, among many others.

Figure 5-20. Illustrated photographs showing the orography of the habitat TB3 in the "Tinença de Benifassà" Natural Park.

TB4 habitat. (Fig. 5-21). This is an area in which there are combined shady areas with channeling runoff into a wooded area of pines and holm. The presence of low scrub and typical understory vegetation is stressesed. One can also cite the presence of *Bupleurum fruticescens* L., *Carduncellus monspeliensium* All., *Carthamus lanatus* L., *Clematis vitalba* L., *Cytisus heterochrous* Webb ex Colmeiro, *Cytisus reverchonii* (Degen & Hervier) Bean, *Euphorbia nicaeensis* All., *Knutia arvensis* (L.) Coulter, *Knutia purpurea* (Vill.) Borbás subsp. *subscaposa* (Boiss. & Reut.) Mateo & Figuerola, *Leuzea conifera* (L.) DC, *Helleborus foetidus* L., *Phlomis lychnitis* L., *Sonchus tenerrimus* L. and *Thalyctrum tuberosum* L., among others.

Figure 5-21. Illustrated photographs showing the orography of the habitat TB4 in "Tinença de Benifassà".

TB5 habitat. (Fig. 5-22). Close zone to the urbanized area of "Tinença de Benifassà" in which there are shady areas favoured by the presence of large poplar that have produced the formations of irregular vegetation that combines the presence of habitats TB3 and TB4.

Figure 5-22. Illustrated photographs showing the orography of the habitat TB5 in "Tinença de Benifassà".

In this habitat the presence of the following plants is cited *Anthemis arvensis* L., *Aristolochia pistolochia* L., *Buxus sempervirens* L., *Carduus pycnocephalus* L., *Euphorbia characias* L., *Knautia purpurea* (Vill.) Borbás subsp. *purpurea, Lathyrus latifolius* L., *Leuzea conifera* (L.) DC., *Medicago orbicularis* (L.) Bartal., *Papaver rhoeas* L., *Reichardia picroides* (L.) Roth, *Rubus ulmifolius* Schott., *Trifolium repens* L. and *Urospermum delechampii* (L.) Scop. Ex. F. W. Schmidt, among others.

Habitat TB6. (Fig. 5-23). Grassy area near the village of Ballestar that consists of a large open area formed by forests of holm. The vegetation collected include species such as *Centaurea triumfettii* All subsp. *semidecurrens* (jord.) O. Bolòs & Vigo, *Cistus albidus* L., *Chenopodium vulvaria* L., *Diplotaxis erucoides* L., *Knautia rupicola* (willk.) Font Quer, *Lathyrus latifolius* L., *Lathyrus saxalitis* (Vent.) Vis., *Lepidium draba* L., *Leuzea conifera* (L.) DC., *Medicago orbicularis* (L.) Bartal, *Medicago sativa* L., *Ononis spinosa* L. subsp. *australis* (Sirj.) Greuter & Burdet, *Phlomis lychnitis* L., *Taraxacum obovatum* (Willd.) DC. and *Vicia hybrida* L.

Figure 5-23. Illustrated photographs showing the orography of the habitat TB6 in the "Tinença de Benifassà" Natural Park.

Habitat TB7. (Fig. 5-24). Area near the town of Ballestar that is present in large zones of abandoned crops. In this area mines of species such as *Centaurea aspera* L., *Coronilla scorpioides* (L.) Kotch, *Hirschfeldia incana* (L.) *Lagrèze-Fossat*, *Medicago* *sativa* L., *Ononis spinosa* L. subsp. *australis* (Sirj.) Greuter & Burdet and *Scabiosa atropurpurea* L. were collected.

Figure 5-24. Illustrated photographs showing the orography of the habitat TB7 in the "Tinença de Benifassà" Natural Park.

<u>Font Roja</u>

In the "Font Roja" Natural Park seven points were selected throughout the highlands (Table 5-2). Some points were given the names to be characterized as flora microreserves (e.g. "Mirador de Pilatos", "Mas de Tetuan", "Menejador", etc.). The studied areas correspond to points located at more than 1000 m. altitude. Basically, they correspond to deciduous forest (Wetter Supramediterranean Floor) and shady holm oak (Supramediterranean floor with subhumid Ombroclimate). The large forests condition a special microclimate that favours the development of some endemic species such as *Salvia blancoana* Webb & Heldr. subsp. *mariolensis* Figuerola and others belonging to areas of less distribution like the "carraspique" (*Iberis carnosa* Willd. subsp. *hegelmaieri* (Willk.) Moreno), the "Valencian pea" (*Lathyrus tremolsianus* Pau), the rupicolous *Saxifraga corsica* Gren. & Godr. subsp. *cossoniana* (Boiss.) D.A. Webb and the "pepper" (*Thymus piperella* L.). Large open areas also exists like in the area of highest elevation of the park (Menejador) where vegetation is conditioned to the existence of rainfall and moderate temperatures. In some areas, such as the "Mas de Tetuan", there are still relics of cereal crops that were produced primarily for consumption in the mid-nineteenth century (Fig. 5-25).

Locality	Code point	GPS (38 Channels)	High
<u>Font Roja</u>	FR1	N38º39'43.1"W00º31'04.0"	1076
	FR2	N38º39'40.5"W00º33'09.8"	1177
	FR3	N38º39'27.0"W00º33'40.7"	1222
	FR4	N38º39'33.2"W00º32'31.4"	1299
	FR5	N38º39.49'4"W00º31'54.4"	1081
	FR6	N38º39'46.6"W00º31'32.9"	1071
	FR7	N38º39'53.9"W00º32'20.8"	1054

Table 5-2. Sampling points studied in the Natural Park of "Font Roja".

Figure 5-25. Illustrated photographs showing different views of the "Font Roja" Natural Park. Top-Left. North side of the park that overlooks the responsible centre for monitoring and managing the park. Top-Right. Plate indicating the consideration of "flora microreserves" of areas with great interest of conservation by the European Union. Bottom-Left. Overview of fields existing into the north plains next to the park. Bottom-Right. Relicts of cereal crops present in the "Mas de Tetuan" flora microreserve.

FR1 habitat. (Fig. 5-26). Place characterized by the location of the Malaise trap. It corresponds to a passage area of insects to be located between two fronts of oak woodlands. The vegetation consists mainly of sunny brushes (e.g. *Prunus spinosa* L., *Quercus coccifera* L., *Rosa micrantha* Borrer and so on) and typical Mediterranean vegetation.

Figure 5-26. Illustrated photographs showing the orography of the habitat FR1 in the "Font Roja" Natural Park.

FR2 habitat (Mirador de pilatos). (Fig. 5-27). It is located half way between the ascension of the "Menejador", is considered a flora microreserve in which the presence of a large biodiversity has been confirmed. Among the vegetation highlighted are *Acer opalus* subsp. *granatense, Astragallus sesameus* L., *Bupleurum fruticescens* L., *Catananche caerulea* L., *Centaurea aspera* subsp. *stenophylla* (Duf.) Nyman, *Centaurea boissieri* DC., *Centaurea mariolensis* Rouy, *Centaurea spachii* Schultz Bip. Ex Willk., *Cistus albidus* L., *Crataegus monogyna* Jacq., *Cytisus heterochrous* Webb ex Colmeiro, *Hirschfeldia incana* (L.) Lagrèze-Fossat, *Leucanthemum gracilicaule* (Dufour) Pau, *Lonicera etrusca* G. Santi, *Lonicera implexa* Aiton, *Mantisalca salmantica* (L.) Briq. & Cavill., *Matricaria chamomilla* L., *Melilotus officinalis* (L.) Pallas, *Ononis fruticosa* L. subsp. *macrophylla* (DC.) Bolòs & al., *Plantago lanceolata* L., *Quercus faginea* Lam., *Quercus ilex* L. subsp. ilex, *Rhamnus alaternus* L., *Saponaria ocymoides* L., *Serratula pinnatifida* (Cav.) Poir, *Silene conica* L., *Silene saxifraga* L., *Silene vulgaris* (Moench) Garcke, *Thymus vulgaris* L., *Trifolium scabrum* L. and *Xeranthemum inapertum* (L.) Mill.

Figure 5-27. Illustrated photographs showing the orography of the habitat FR2 in the "Font Roja" Natural Park.

FR3 habitat (Mas de Tetuan). (Fig. 5-28). Place located half a kilometre from the top of the mountains, characterized by the presence of crops and anthropized areas that have had an important role in the subsistence economy of the nineteenth century. Among the mined vegetation collected in this zone different species are highlighted such as *Arrhenatherum elatius* (L.) P. Beauv. Ex J. & C. Presl, *Bupleurum fruticescens* L., *Centaurea aspera* subsp. *stenophylla* (Duf.) Nyman, *Cirsium vulgare* (Savi) Ten., *Coronilla scorpioides* (L.) Kotch, *Crepis albida* Vill., *Crepis vesicaria* L., *Cynoglossum cheirifolium* L., *Diplotaxis erucoides* (L.) DC, *Hirschfeldia incana* (L.) Lagrèze-Fossat, *Hordeum murinum* L. subsp. *leporinum, Leontodon taraxacoides* (Vill.) Mérat, *Lonicera etrusca* G. Santi, *Lonicera implexa* Aiton, *Lotus corniculatus* L., *Mantisalca salmantica* (L.) Briq. & Cavill., *Medicago lupulina* L., *Medicago minima* L., *Medicago sativa* L., *Papaver rhoeas* L., *Phlomis lychnitis* L., *Plantago lagopus* L., *Plantago lanceolata* L., *Quercus faginea* Lam., *Quercus ilex* L. subsp. *ilex*, *Quercus ilex* subsp. *rotundifolia, Rapistrum rugosum* (L.) All., *Scabiosa atropurpurea* L., *Scorzonera laciniata* L., *Senecio vulgaris* L., *Serratula pinnatifida* (Cav.) Poir, *Silene secundiflora* Othh, *Sinapis alba* L., *Sisymbrium orientale* L., *Sonchus oleraceous* L., *Sysimbrium irio* L., *Sysimbrium orientale* L., *Taraxacum obovatum*(Willd.) DC. and *Xeranthemum inapertum* (L.) Mill.

Figure 5-28. Illustrated photographs showing the orography of the habitat FR3 in the "Font Roja" Natural Park.

FR4 habitat (Menejador). (Fig. 5-29). It corresponds to the highest point in the park. It is characterized by an open area in which strong winds blow. It is an area where the vegetation suffers from direct sunlight, thus in absence of rain it begins to disappear in mid-June. Among the most important plant species for Agromyzidae are *Anthyllis vulneraria* subsp. *praepropera, Brachypodium retusum* (Pers.) P. Beauv., *Carduncellus monspelliensium* All., *Centaurea rouyi* Councy, *Centaurea scabiosa* L. subsp. *cephalariifolia* (Willk.) Rivas Goday & Borja, *Centaurea solstitialis* L., *Cistus clusii* Dunal, *Convolvulus althaeoides* L., *Crepis albida* Vill., *Dactylis glomerata* L., *Iberis saxatilis* L. subsp. *saxatilis, Lonicera etrusca* G. Santi, *Lotus corniculatus* L., *Medicago suffruticosa* Ramond ex DC. in Lam. et DC., *Plantago lanceolata* L., *Quercus faginea* Lam., *Serratula pinnatifida* (Cav.) Poir, *Sisymbrium crassifolium* subsp. *laxiflorum* (Boiss.) O. Bolòs & Vigo, *Sysimbrium orientale* L. and *Teucrium ronnigeri* Sennen.

Figure 5-29. Illustrated photographs showing the orography of the FR4 habitat in the "Font Roja" Natural Park.

FR5 habitat. (Fig. 5-30). It corresponds to a path that runs between the lush forests of oak and maple. It is located towards the southern slopes and is characterized by promoting the development of seedlings of shade. Between the mined vegetation that was found here included are species such as *Acer opalus* subsp. *granatense* (Boiss.) Font Quer & Rothm, *Colutea arborescens* L., *Lepidium draba* L., *Leucanthemum gracilicaule* (Dufour) Pau, *Lonicera etrusca* G. Santi, *Plantago lagopus* L., *Quercus ilex* L. subsp. *ilex, Quercus ilex* subsp. *rotundifolia* (Lam.) Schwartz ex T. Morais, *Rhamnus alaternus* L., *Serratula pinnatifida* (Cav.) Poir, *Sonchus oleraceous* L. and *Sysimbrium irio* L.

Figure 5-30. Illustrative photographs showing the orography of the habitat FR5 in the "Font Roja" Natural Park.

FR6 habitat. (Fig. 5-31). It is composed of large areas of cultivated cereals (e.g. wheat), that run between hillsides of lush forests. Fertilization of these fields make it possible to develop a wide variety of plants in which a large amount of insects in spring are gathered. Particularly striking are the blooms of *Papaver rhoeas* L. in mid-May. Among the vegetation that make up these grasslands are *Andryala integriflora* L., *Avena barbata* Pott ex Link, *Avena sativa* L., *Avena sterilis* L., *Bupleurum rigidum* L., *Carduus pycnocephalus* L., *Catananche caerulea* L., *Centaurea rouyi* Coincy, *Cirsium arvense* (L.) Scoop., *Cytisus reverchonii* (Degen & Hervier) Bean, *Diplotaxis erucoides* (L.) DC, *Heliotropium europaeum* L., *Lithospermum arvense* L., *Medicago sativa* L., *Phlomis lychnitis* L., *Picnomon acarna* (L.) Cass., *Plantago lagopus* L., *Plantago lanceolata* L., *Reseda stricta* Pers., *Senecio vulgaris* L., *Serratula pinnatifida* (Cav.) Poir, *Silene secundiflora* Othh, *Sonchus oleraceous* L., *Sonchus tenerrimus* L. and *Vicia sativa* L.

Figure 5-31. Illustrative photographs showing the orography of the habitat FR6 in the "Font Roja" Natural Park.

FR7 habitat. (Fig. 5-32). Area located next to the response centre for the care of the park. The typical vegetation of the park board with care gardens in which it gives rise to the proliferation of a large number of plant species often undermined by Agromyzidae, we highlight *Crepis vesicaria* L., *Dactylis glomerata* L., *Hirschfeldia* *incana* (L.) Lagrèze-Fossat, *Lepidium draba* L., *Malva parviflora* L., *Medicago sativa* L., *Silene conoidea* L., *Silene dioica* (L.) Clairv., *Silene vulgaris* L., *Sonchus oleraceous* L., *Sysimbrium irio* L., *Taraxacum obovatum* (Willd.) DC. and *Urospermum picroides* (L.) Scop. Ex F. W. Schmidt.

Figure 5-32. Illustrative photographs showing the orography of the habitat FR7 in the "Font Roja" Natural Park.

Lagunas de La Mata-Torrevieja

The selected points are next to the "Lagunas de La Mata-Torrevieja" (Table 5-3). The total distance sampled is about around a linear kilometre in which several areas of about 100m^2 were selected. The particularity of the flora of this lagoon makes certain areas of flora change considerably, while in others the differences are not significant (Fig. 5-33).

Locality	Code point	GPS (38 Channels)	High
Lagunas de La Mata-Torrevieja	TRV1	N38º01'19.7"W00º40'54.2"	6
	TRV2	N38º01'35.6"W00º41'21.1"	2
	TRV3	N38º01'48.8"W00º42'00.1"	5
	TRV4	N38º01'56.6"W00º42'19.7"	4
	TRV5	N38º01'57.2"W00º42'37.9"	4
	TRV6	N38º01'56.9"W00º42'43.0"	9
	TRV7	N38º01'15.7"W00º43'49.1"	6
	TRV8	N38º01'38.8"W00º41'27.5"	5
	TRV9	N38º01'56.6"W00º42'09.4"	4
	TRV10	N38º01'57.2"W00º42'37.9"	5

Table 5-3. Sampling points studied in the Natural Park of "Lagunas de La Mata-Torrevieja".

Figure 5-33. Illustrated photographs showing different views of the “Lagunas de La Mata-Torrevieja” Natural Park. Top-Left. Panoramic view of the carrizal-juncal zone. Top-Right. Panoramic view opposite to the shore of the lagoon showing the formation of pine forests. Bottom-Left. View of the lagoon showing the proximity of the town of Torrevieja. Bottom-Right. Plate indicating the consideration of “flora microreserves” of areas with great interest of conservation by the European Union.

TRV1 habitat. (Fig. 5-34). It corresponds to an area of Carrizal-Juncal with the presence of typical species of salt bordering the lagoon. It highlights species such as *Arthrocnemum macrostachyum* (Moric.) Moris, *Avena fatua* L., *Dittrichia viscosa* (L.) Greuter, *Euphorbia serrata* L., *Foeniculum vulgare* Mill., *Halimione portulacoides* (L.) Aellen, *Helianthemum almeriense* Pau subsp. *scopulorum* (Rouy) Alcaraz & al., *Helianthemum lavandulifolium* Mill., *Hippocrepis comosa* L., *Inula crithmoides* L., *Limonium cossonianum* Kuntze, *Limonium supinum* (Girard) Pignatti, *Medicago minima* L., *Medicago sativa* L., *Phragmites australis* (Cav.) Trin. Ex Steud, *Plantago lagopus* L., *Reichardia intermedia* (Schulz Bip.) Cout., *Reichardia tingitana* (L.) Roth, *Senecio auricula* Bourg. Ex. Coss., *Sonchus oleraceous* L., *Sonchus tenerrimus* L., *Thapsia villosa* L. and *Thymelaea hirsuta* (L.) Endl.

Figure 5-34. Illustrated photographs showing the orography of the habitat TRV1 in the "Lagunas de La Mata-Torrevieja" Natural Park.

TRV2 habitat. (Fig. 5-35). It is an open area where the salt marsh vegetation is displaced by the presence of typical mountain species close to pine forests. In late and early spring broad-leaved plants are predominant, then the high temperatures causes plants with narrow leaves and grasses to crowd out the above and are present in virtually all parts of these areas.

Figure 5-35. Illustrative photographs showing the orography of the TRV2 habitat in the "Lagunas de La Mata-Torrevieja" Natural Park.

Among the vegetation undermined by Agromyzidae it stresses the presence of *Anagallis arvensis* L., *Asparagus maritimus* (L.) Mill., *Asphodelus ramosus* L., *Asteriscus maritimus* (L.) Less, *Avenula bromoides* (Gouan) H. Scholz, *Bromus fasciculatus* Presl, *Calendula arvensis* L., *Carrichtera annua* (L.) DC, *Centaurea aspera* L. (Dufour) Nyman, *Centaurea rouyi* Coincy, *Cistus albidus* L., *Cistus clusii* Dunal, *Convolvulus althaeoides* L., *Diplotaxis erucoides* (L.) DC, *Erodium malacoides* L., *Euphorbia paralias* L., *Euphorbia serrata* L., *Galium verrucosum* Huds., *Helianthemum guerrae* Sánchez Gómez & al., *Hordeum murinum* L., *Ononis ornithopodioides* L., *Phagnalon saxatile* (L.) Cass, *Piptatherum miliaceum* (L.) Coss., *Pistacia lentiscus* L., *Plantago lagopus* L., *Scabiosa atropurpurea* L., *Silene vulgaris* (Moench) Garcke, *Sonchus oleraceous* L., *Thapsia villosa* L., *Thymus vulgaris* L. and *Urospermum picroides* (L.) Scop. Ex. F.W. Schmidt.

TRV3 habitat. (Fig. 5-36). A terracing area that was cultivated in the early twentieth century and which now corresponds to open areas that run between pine forests and in which important vegetation susceptible to be undermined by Agromyzidae is developed such as *Asteriscus maritimus* (L.) Less, *Atriplex patula* L., *Avena barbata* Pott ex Link, *Ballota hirsuta* Benth., *Bellardia trixago* (L.) All., *Beta maritima* L., *Centaurea aspera* L. subsp. *stenophylla* (Dufour) Nyman, *Convolvulus althaeoides* L., *Chenopodium murale* L., *Geranium molle* L., *Hyoscyamus albus* L., *Lactuca sativa* L., *Marrubium vulgare* L., *Medicago polimorpha* L., *Nonea vesicaria* (L.) Rchb., *Ononis ornithopodioides* L., *Papaver rhoeas* L., *Parietaria judaica* L., *Pipthaterum miliaceum* (L.) Cosson, *Plantago lagopus* L., *Sonchus oleraceous* L., *Reichardia picroides* (L.) Roth, *Rumex crispus* L., *Setaria viridis* (L.) P. Beauv., *Silene vulgaris* (Moench) Garcke, *Sisymbrium irio* L., *Sonchus tenerrimus* L., *Taraxacum obovatum* (Willd.) DC. and *Vicia villosa* Roth.

Figure 5-36. Illustrative photographs showing the orography of the TRV3 habitat in the "Lagunas de la Mata-Torrevieja" Natural Park.

TRV4 and TRV5 habitats. (Fig. 5-37). Neighbouring areas in which a similar flora develops. They are next to the lagoon and in which plants such as *Anagallis arvensis* L., *Asteriscus maritimus* (L.) Less, *Avena sativa* L., *Chrysanthemum coronarium* L., *Convolvulus althaeoides* L., *Pistacia lentiscus* L., *Plantago lagopus* L., *Scabiosa atropurpurea* L., *Sonchus oleraceous* L. and *Thymelaea hirsuta* (L.) Endl. are developed.

Figure 5-37. Illustrative photographs showing the orography of the TRV4 habitat (left) and TRV5 (right) in the "Lagunas de La Mata-Torrevieja" Natural Park.

TRV6 habitat. (Fig. 5-38). Open areas of cereal cultivation in which their tillage leads to the development of other plants. Among the Agromyzidae vegetation mined in the area it highlights the presence of *Asphodelus fistulosus* L., *Atriplex halimus* L., *Avena byzanthina* C. Koch, *Avena sativa* L., *Diplotaxis erucoides* (L.) DC, *Erodium malacoides* L., *Euphorbia serrata* L., *Plantago lagopus* L., *Silene vulgaris* (Moench) Garcke, *Sisymbrium officinale* (L.) Scoop., *Sonchus oleraceous* L. and *Sonchus tenerrimus* L.

Figure 5-38. Illustrative photographs showing the orography of the TRV6 habitat in the "Lagunas de La Mata-Torrevieja" Natural Park.

TRV7 habitat. (Fig. 5-39). An area of low scrub between sparsely populated pine forests that are adjacent to urbanized areas. It is characterized by the presence of low biodiversity in which virtually no plants mined by Agromyzidae is found. Some of the broad-leaved species found are *Sisymbrium irio* L., *Sonchus oleraceous* L., *Taraxacum obovatum* (Willd.) D.C. and *Vicia villosa* Roth.

Figure 5-39. Illustrative photographs showing the orography of the TRV7 habitat in the "Lagunas de La Mata-Torrevieja" Natural Park.

TRV8 habitat. (Fig. 5-40). Zone next to TRV2 habitat in which it highlight the large development of species such as *Asphodelus ramosus* L., *Asteriscus maritimus* (L.) Less and *Limonium cossonianum* Kuntze.

Figure 5-40. Illustrative photographs showing the orography of the TRV8 habitat in the "Lagunas de La Mata-Torrevieja" Natural Park.

TRV9 habitat. (Fig. 5-41). It corresponds to the area in front of an islet present in the lagoon of La Mata.

The vegetation is typical of the salt marsh highlighting the presence of *Coronilla scorpioides* (L.) Kotch, *Aizoon hispanicum* L., *Chrysanthemum coronarium* L., *Convolvulus althaeoides* L., *Echium vulgare* L., *Eruca vesicaria* (L.) Cav., *Galium verrucosum* Huds., *Medicago polymorpha* L., *Piptatherum miliaceum* (L.) Coss., *Plantago lagopus* L., *Rumex crispus* L., *Senecio auricula* Bourg. Ex. Coss, *Senecio vulgaris* L., *Serratula flavescens* (L.) Poir. subsp. *leucantha* (Cav.) Cantó & M.J. Costa, *Sysimbrium irio* L., *Sonchus oleraceous* L. and *Sonchus tenerrimus* L.

Figure 5-41. Illustrative photographs showing the orography of the TRV9 habitat in the "Lagunas de La Mata-Torrevieja" Natural Park.

TRV10 habitat. (Fig. 5-42). Open area adjacent to the TRV9 area in which it develops a wide variety of plant species that could be mined by Agromyzidae such as *Asteriscus maritimus* (L.) Less, *Avena barbata* Pott ex Link, *Carduus pycnocephalus* L., *Centaurea melitensis* L., *Convolvulus althaeoides* L., *Coronilla scorpioides* (L.) Kotch, *Chenopodium murale* L., *Chrysantemum coronarium* L., *Cynoglossum cheirifolium* L., *Diplotaxis erucoides* (L.) D.C., *Emex spinosa* (L.) Campd., *Hordeum murimum* L. subsp. *leporinum* (Link) Arcang., *Medicago minima* L., *Plantago lagopus* L., *Rumex crispus* L., *Serratula flavescens* (L.) Poir. *subsp. leucantha* (Cav.) Cantó & M.J. Costa, *Sonchus oleraceous* L., *Sonchus tenerrimus* L. and *Urospermum picroides* (L.) Scop. Ex F. W. Schmidt.

Figure 5-42. Illustrative photographs showing the orography of the TRV10 habitat in the "Lagunas de La Mata-Torrevieja" Natural Park.

5.2.3 Capture system

The different capture systems used include the collection of mined plants, the usage of entomological sleeves and the placement of entomological traps for flight interception.

Collection of mined plants

The establishment of Agromyzidae interactions with their host-plants has been possible through the visual identification of plants mined (usually leaves and stems).

The collection of mined plants is carried out directly by trying to take a representative part of the plant, possibly with the root system. The transport is carried out by separating the samples in polyethylene bags and inside a cooler to keep the material of plants in good condition until they arrive in the laboratory. Labelling and botanical identification of plants is essential for a suitable sampling. The labelling should include the date of collection, the botanical identification of the plant, the collection place and a summary of the plant ecology.

Once mined material is transported to the laboratory it must be conditioned in plastic boxes with perforated metal grill until after the pupation occurs it produces the emergence of the miners. The conditions of temperature and humidity of the climatic chamber were 25±1ºC and 65±5% RH.

The samples were revised every 2-3 days. The emerged miners were previously stunned with CO2 and then placed in cryovials of 1.5 ml (kept in alcohol at 70º). Then they proceeded on to the systematic study of specimens obtained.

Entomological sleeve

The entomological sleeve consists of an active collection system for interception of the flight of insects. The operator must shake the sleeve from side to side and they go on capturing insects. It is a system that requires experience to know where to sample, at what soil height do it on and on what plants.

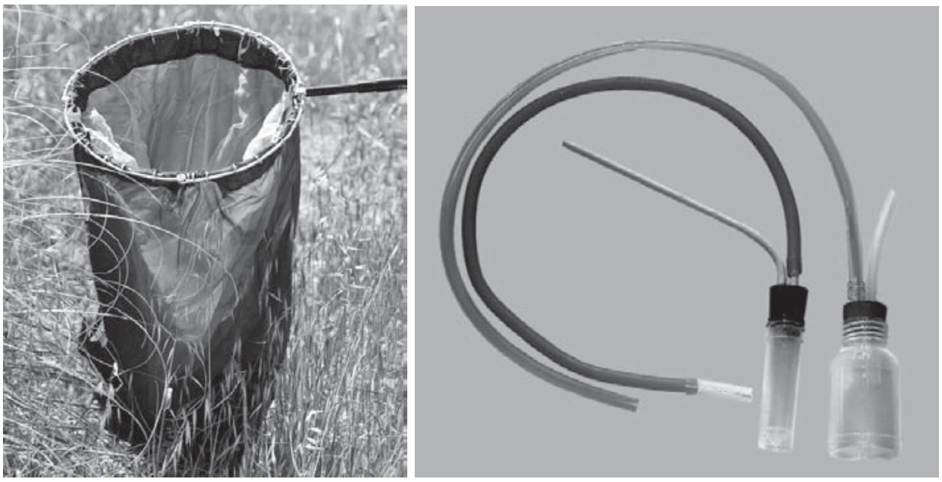


Figure 5-43 Entomologycal sleeve (left) and aspirators of suction not mechanized (Right) (Source: *http://www. entomopraxis.com*)

The system consists of a metal frame (usually aluminium) like a butterfly net. It is usually used like a receptor organ of insects because the material dries quickly and does not allow the escaping of the material by the passage diameter of the fabric holes. The diameter of the collector ring is approximately 35 cm. It can take a white interior and green exterior (to pass unnoticed), both of 68 cm of deep. This system is suitable for shaking on little hard vegetation. The handle is simple and lightweight of about 70 cm. Insects collecting is done by suction using an aspirator (Fig. 5-43).

Malaise Trap

It was invented by RENÉ EDMOND MALAISE (1937) and has demonstrate a large efficacy for captureing dipterans and hymenopterans (NIEVES-ALDREY & REY DEL CASTILLO, 1991). It is considered an adequate and widespread method for phenologycal monitoring populations of Agromyzidae (von-TSCHIRNHAUS, 1992).

The model used was G700 (Entomopraxis-Barcelona-Spain), which is a slightly modified version of H. TOWNES (1962, 1972) (Figs. 5-44, -45, -46). It is a mesh set arranged in a tent that is open at the bottom. When insects enter or crash against the mesh, they try to get out by going up, where they encounter a capture container with preservative (alcohol 70º, usually). In this way a large quantities of flying insects are captured. The length is greater than 2 m. The orientation path of traps for a good efficacy of captures must be southwest and in pass zone without a lot wind.

The traps are usually kept permanently in the field and the collection samples are carried out on a weekly basis especially in periods of high reproductive activity.

In total three Malaise traps were placed, one for each park, in transit areas and in strategic locations where the presence of a good fauna representation was expected and the possible existence of new species were not recorded so far. One disadvantage of this system, particularly for Agromyzidae captures, is that the species captured that have not yet been cited means that it is impossible to know the host-plants, which requires an extra effort by searching and collection of miners from detection of mines produced in plants.

Figure 5-44. Malaise trap placed in the "Tinença de Benifassà" Natural Park.

Figure 5-45. Malaise trap placed in the "Font Roja" Natural Park.

Figure 5-46. Malaise trap placed in the “Lagunas de La Mata-Torrevieja” Natural Park.

5.2.4 Preparation and conservation of Agromyzidae specimens

The difficulty of the preparation and preservation of the Agromyzidae material lies in their small size and their specific identification based on the morphological analysis of the genitalia. Different systems for preparation and preservation of material exist in the case that we deal with flies, or their genitalia. The more common systems used are cited the case of Agromyzidae.

Flies

Specimens collected with entomological sleeves may be stored in cool (freezer) conditions or generally in alcohol. The use of the Malaise traps implies that the method of preservation is fluid, with the alcohol 70º being the most commonly used.

Before the specimens assembly and their labelling takes place, the material must be dried while retaining their morphological characteristics intact. To do this the most common method used is cited by GORDH & HALL (1979) and it consists of the replacement of all liquids gas carbon dioxide gas.

The specimens to be processed are passed through an alcohol series, using successive alcohols of increasing degree, up to 100% and keeping them there for 30 minutes at each concentration. The last step with alcohol 100% should be done twice in total.

Then, it is introduced into a drying chamber containing CO_2 liquid at 5ºC, increasing the temperature and pressure to reach the critical point (43ºC and 100 bar) and then slowly decreasing both variables to room temperature (VERDÚ, 1989).

In a practical way it is possible to conserve the specimens inside tubes with glycerol, this will keep for years. In the case of making an entomological collection the most correct way is mounting the dry material.

Preparing of the male genitalia

For preparing of the male genitalia, we have used and recommend the following method, slightly modified from WHEELER & KAMBYSELLIS (1966) and KANESHIRO (1969):

1. Soften the pinned flies by placing them in a humid chamber at room temperature (ca. 24ºC), for ca. 6 hours if naturally dried, or 24 hours if chemically dried. Longer wetting may cause the wings to stick to each other or to the body. Before relaxing a specimen, it is important to take note of some surface features (brightness, ornamentation, etc.) which may change during the process. In addition, labels fixed to the pins should be temporarily removed and substituted by coded numbers to avoid a possible smudging of the text. We recommend that flies stored in ethanol be pinned and dried before preparation.

2. Clip the distal 2/3 of the abdomen with a pair of micro scissors, then pick it up with the slightly wet tip of a piece of soft paper and place it in a small glass tube (ca. 1.5 ml) with 10% KOH (to maintain transparency always store KOH solution in a plastic vial, never in a glass container). Before being returned to the collection, the pinned specimen must be air-dried.

3. Place the tube in a bath of boiling water for ca. 30 min. Do not overheat the KOH solution over a direct flame.

4. Carefully wash out the KOH completely by pouring the contents of the tube into a funnel lined with filter paper and then squirting distilled water ad libitum over the abdomen.

5. After washing the tube with distilled water, add a small amount (ca. 0.5 ml) of stain (four parts of Gage's stain with one part of glacial acetic acid), put the abdomen back into the tube, and keep it in a bath of boiling water for ca. 30 min. For Gage's stain mix 0.5 g of acid fuchsine, 25 ml of 10% HCl and 300 ml of distilled water. Use very soft aluminium tweezers to pick the abdomen out of the liquids, and never let it dry out or stick to the filter paper lining the funnel.

6. Wash the abdomen with 95% ethanol as in item 4.

7. Transfer the abdomen to a cavity slide containing a minute drop of creosote (obtained by just touching the cavity with the tip of a pipette with creosote).

8. Disarticulate first the tergites and sternites from the terminalia. After carefully locating the membranous articulation points, separate the epandrium from the

hypandrium, and finally the aedeagus from the hypandrium, if necessary. For the disarticulation of the structures and the removing of membranous tissues, use a pair of micro dissecting needles consisting of minute pins inserted into a shortened wooden chopstick or matchstick.

9. Over staining that is discovered when the abdomen is in creosote can be reversed by returning it to ethanol, then distilled water and back to 10% KOH, and then restarting the staining procedure.

10. For preparing ink drawings or for photographs, the sclerites are individually mounted on glass slides using natural Canada balsam as the medium. Before adding the cover glass, place four small pieces of broken cover glass around the small drop of balsam. For thicker objects, e.g. the epandrium of most species, use two strips of cardboard (ca. 5 mm x 20 mm) instead; two index cards gummed together are about the right thickness. Allow some days for the balsam to get a little denser. Gently push the cover glass to move the structure into the desired position. Afterwards, use xylene to soften the Canada balsam and to remove the objects from slides; transfer them first to creosote for some minutes, or even some hours, then to 95% ethanol for some minutes, then pour a drop of glycerine over the sclerites, and finally transfer them to pure glycerine.

11. Put the sclerites in a micro vial filled with pure glycerine and attach it by the stopper to the pin of the specimen from which the abdomen originated (Fig. 5-47).

At least steps 1 to 7 should be carried out for identification; however, step 5 may be skipped for non-teneral, dark specimens. Anaesthetized flies can often be identified without dissection, used the method proposed by SPASSKY (1957). Gentle pressure on the subdistal area of the abdomen (insect laterally positioned, left side up), with the aid of a pair of insect pins, causes the aedeagus and associated structures to evert, and then the species can be identified.

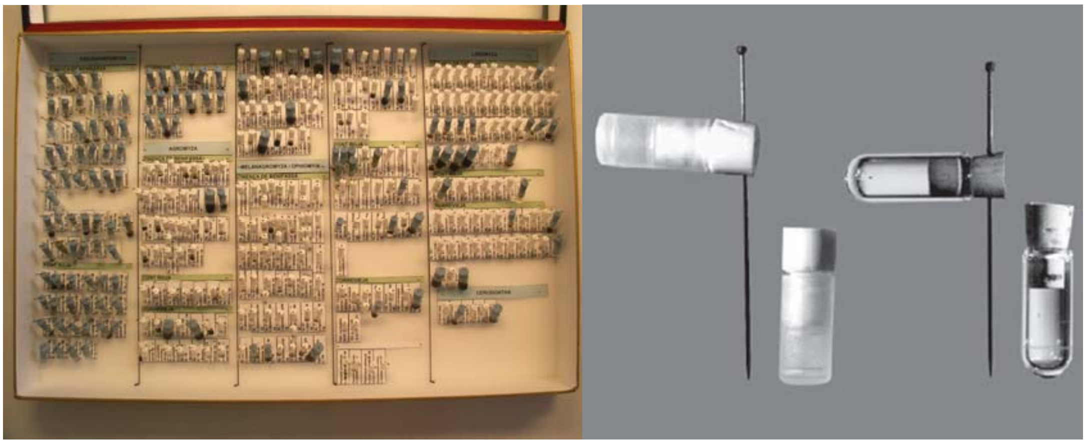


Figure 5-47. Agromyzidae material classified and labelled, preserved in glycerine to be identified from the male genitalia (left). Microvials used for conservation of the Agromyzidae genitalies. Diameter 6 mm, length 12 mm, polyethylene with a rubber stopper. It allows save the insect genitalia mounted with the pin and store them (right).

5.2.5 Material analysis

The material used for the specimens analysis of Agromyzidae consisted of a steoroscopic microscope LEICA MS 5.

Photographs of this thesis were performed at INRA-Montpellier and carried out with a JVC Digital Camera make KY-F75 U SDK. The program used was Perfect Image Version 7.1.

5.3. Inventory of species captured in the studied areas

The list of species shows the location areas of miners in Europe according to MARTINEZ (2004). The host-plants appointment are in agreement with BENAVENT-CORAI *et al.* (2005). The diagnostic characters are also indicated for species identification, as well as indications of the species phenology.

5.3.1 Subfamily *Agromyzinae*

5.3.1.1 Genus ***Agromyza*** Fallén, 1810

Agromyza genus comprises 99 species in the Palaearctic region. MARTINEZ (2004) cites the presence of 72 species in Southwestern Europe, and 34 in continental Spain. In the present thesis is reported the occurrence of 4 new reports: *Agromyza anthracina* Meigen, 1830; *Agromyza bromi* Spencer, 1966; *Agromyza hiemalis* Becker, 1908 and *Agromyza megalopsis* Hering, 1933.

Diagnostic characters: sub-costa well developed and joining *R1* before reaching costa; either 3+1 strong dorso-centrals or 3 or more post-sutural *dc*, greatly decreasing in size, with any presutural small and weak; orbital setulae reclinate; pre-scutellars present; second cross-vein normally present, discal cell large; stout species, wing length ranges from 1.45-3.5 mm; most species entirely dark but a number with frons reddish or yellow; halteres also white or yellow; stridulating mechanism present in both sexes (SPENCER, 1972b; SPENCER, 1976a).

Based on host-plants, the *Agromyza* genus is divided into 4 groups: the *nigripes* group feeding on Graminae; the *potentillae* group mainly on Rosaceae but also on Betulaceae, Geraniaceae, Polygonaceae and Salicaceae; the *rufipes* group feeding on Boraginaceae, Compositae, Urticaceae, and other groups associated with Leguminosae (SPENCER, 1976a). The vast majority of species with host-plants are known as leaf-miners, but may also be stem-miners or gall-causers. Most larvae form blotch mines or wide linear mines after reaching their third instar. Pupation always occurs outside of the mine, usually in the soil. However, in swamp areas puparia glued on their host plant surface can be observed frequently (DEMPEWOLF, 2004).

Species has been found in this genus belonging to the Natural Parks of "Tinença de Benifassà" and "Lagunas de La Mata-Torrevieja". Failure to observe captures in "Font Roja" is attributed to placing the trap in an area with typical vegetation of *Quercus*.

Phenology captures in the Natural Park of "Tinença de Benifassà" (Fig. 5-48) indicate a high annual fluctuation throughout the years associated with the lack of rain during the years 2004 and 2005. In 2006, 3 generations of males and females are observed in the spring, and another generation very high (> 20 males/week) in autumn. Female populations during this last period are of the order of 3-4 times lower. Average temperatures in which captures were higher are established at about 20ºC.

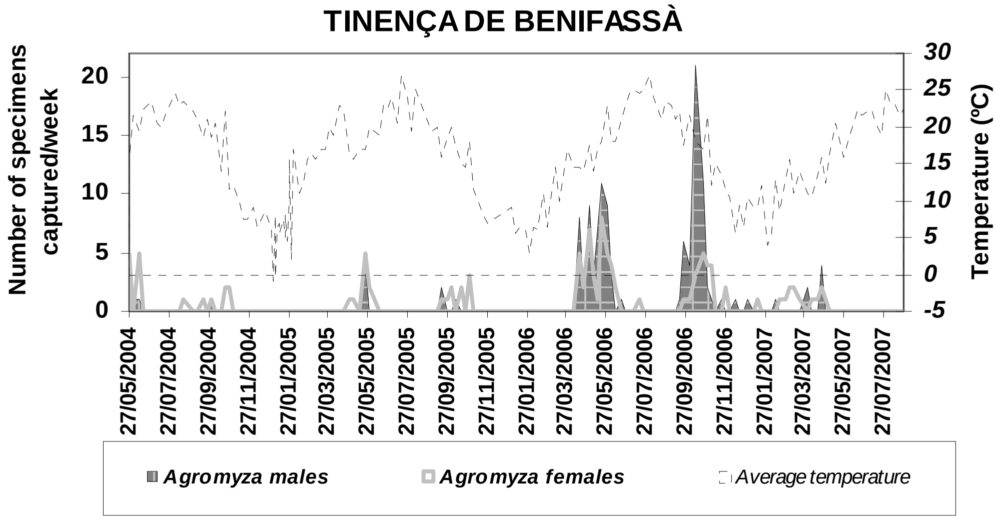


Figure 5-48.- Space-time evolution of the captures of males and females of the *Agromyza* genus in the Natural Park of "Tinença de Benifassà".

In the Natural Park of "Lagunas de La Mata-Torrevieja" a significant difference in captures are observed between years. Female predominance is noted in periods where host-plants are present, normally from late October until mid-May. Then, high daytime temperatures (>40°C) destroy practically all broadleaf annual flora. Optimum mean temperatures are set between 15-25ºC, in this case the shortage of rainfall is the factor that most determines the host-plants presence. The number of generations is variable, with a high peak from mid-autumn until late spring, or 3-5 generational peaks determined by weather conditions (Fig. 5-49).

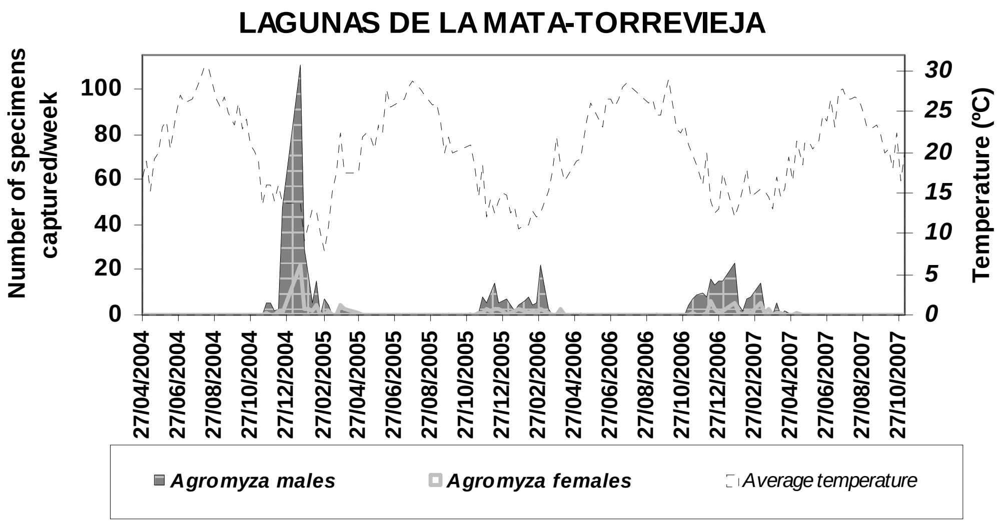


Figure 5-49. Space-time evolution of the captures of males and females of the *Agromyza* genus in the Natural Park of "Lagunas de La Mata-Torrevieja".

Agromyza abiens Zetterstedt, 1848

= *Agromyza echii* Kaltenbach, 1860

Material examined: Tinença de Benifassà: 1♂, 24.iv.2006-1.v.2006; 1♂, 8-15.v.2006; 1♂, 15-22.v.2006.

Diagnostic characters: Large species with orange frons and broad epistoma. Frons pale, reddish-orange, orbits sometimes darker, all antennal segments generally similar to frons but third may be darker, brownish-balck; broad epistoma present; jowls deeply extended at rear; Mesonotum with colour mat grey, with 5 or more *dc*, greatly decreasing in size; femora black but all knees broadly yellow, tibiae and tarsi yellow; Wings length from 2.8-3.5 mm, costa extending strongly to vein M_{1+2}; last section of M_{3+4} short, from ½ to 2/3 penultimate; wing base pale, from whitish to yellowish-brown, squamae and fringe white to pale yellow. Male genitalia.- Aedeagus as in SPENCER, 1976a: 88.

Distribution: Palaearctic: Austria, Britain I., Corsica (doubtful), Czech Republic, Danish mainland, Finland, French mainland, Germany, Hungary, Ireland, Italian mainland, Lithuania, Malta, Norwegian mainland, Poland, Romania, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; North Africa.

Host-plants: *Anchusa, Asperugo, Cerinthe, Cynoglossum, Echium, Lappula, Myosotis, Nonea, Omphalodes, Podonosma, Pulmonaria, Symphytum.*

This is a close species to *Agromyza myosotidis* Kaltenbach, 1864 in which the main difference is the striking colour, first it is yellow and grey, and the second it is largely black. Into Boraginaceae family, *A. abiens* occurs on *Anchusa*, *Lycopsis*, *Nonea*, *Pulmonaria*, and *Symphytum*. And *A. myosotidis*, a largely black species, has been recorded in this family on *Anchusa*, *Borago* and *Symphytum*.

Phenology: This species occurs in "Tinença de Benifassà" in spring.

Agromyza apfelbecki Strobl, 1902

= *Agromyza andalusiaca* Strobl, 1906

Material examined: Tinença de Benifassà: 1♂, 22-29.iv.2005; 2♂, 16-23.v.2005; 2♂, 6-17.iv.2006; 1♂, 17-24.iv.2006; 1♂, 12-23.x.2006; Lagunas de La Mata-Torrevieja: 1♂, 28.iii.2006-4.iv.2006; 1♂, 5-12.xii.2006.

Systematic description: Very large species, wing length up to 4.2 mm, frons and antennae reddish. Frons exceptionally broad, 2 ½-3 times width of eye, conspicuosly projecting above eye in profile; normally 2 *ors* and 2 *ori* but 1 or even 2 additional bristles may be present; orbital setulae short, reclinate; jowls deeply extended at rear, cheeks forming broad ringe below eye; third antennal segment ovoid, arista short, only finely pubescent; conspicuously high epistoma above mouth-margin. Mesonotum with dorso-central bristles strong, variable but normally 4+2; acrostichals in some 6 rows. Wing length from 3.4 mm in male to 4.2 mm in female; costa extending extrongly to vein M_{1+2}, last section of M_{3+4} short, little mora than ½ length of penultimate, first cross-vein at or slightly before midpoint of discal cell. Frons reddish, hind margin of eye and orbits greyish-black, with silvery pruinosity; all antennal segments reddish, third variably darkened towards apex; mesonotum and abdomen mat, ash-grey; legs black but all knees distinctly reddish; squamae pale grey, fringe black. Male genitalia.- Aedeagus as in SPENCER, 1973: 149, surstyli with a patch of strong bristles on inner face.

Distribution: Palaearctic: European Turkey, French mainland, Germany, Greek mainland, Italian mainland, Malta, Sicily, Spanish mainland, Yugoslavia; Neotropical region.

Host-plants: *Carduus, Cirsium, Cynara.*

Agromyza apfelbecki is one of the largest *Agromyza* species with its wing length up to 4.2 mm and mines along the midrib with short offshoots into the leaf blade on *Cirsium*, *Carduus* and *Cynara*. It occurs primarily in the Mediterranean area where it is invariably present on cultivated *Cynara scolymus* L. (globe artichoke), and has also been introduced to Chile with this plant.

Phenology: It is present in Spring and Autumn in both, “Tinença de Benifassà” and “Lagunas de La Mata-Torrevieja”.

Agromyza conjuncta Spencer, 1966

Material examined: <u>Tinença de Benifassà</u>: 1♂, 20-25.v.2004; 2♂, 24.iv.2006-1.v.2006; 1♂, 16-23.iv.2007; <u>Lagunas de La Mata-Torrevieja</u>: 3♂, 26.i.2005-2.ii.2005; 2♂, 1-8.iii.2005; 1♂, 29.iii.2005-5.iv.2005; 1♂, 19-26.iv.2005; 1♂, 14-21.ii.2006; 5♂, 21-28.ii.2006; 2♂, 28.ii.2006-14.iii.2006; 1♂, 4-11.iv.2006; 2♂, 19-26.xii.2006; 3♂, 26.xii.2006-2.i.2007; 11♂, 2-24.i.2007; 4♂, 24-30.i.2007; 1♂, 30.i.2007-6.ii.2007; 5♂, 6-13.ii.2007; 4♂, 13-20.ii.2007; 11♂, 20.ii.2007-6.iii.2007; 3♂, 6-13.iii.2007; 3♂, 27.iii.2007-3-iv.2007; 1♂, 10-17.iv.2007; 1♂, 1-8.v.2007.

Key diagnostic characters: SPENCER, 1966b: 286.

Distribution: Palaearctic: Belgium, Britain I., Crete, Czech Republic, Dodecanese Is., French mainland, Germany, Italian mainland, Poland, Sicily, Slovakia, Spanish mainland, Yugoslavia.

Host-plants: Unknown.

A. conjuncta is commonly present in Southern Europe but has been recorded in Scotland. Its hosts are not known but it obviously feeds on Poaceae.

Phenology: It is present in spring in “Tinença de Benifassà” and in “Lagunas de La Mata-Torrevieja” it is widely present from early winter to mid-spring when temperatures become very high. Usually there are 4-5 generations with maximum populations established when average temperatures range between 15-20ºC. The highest recorded generation peak occurred in the winter of 2004 with 10 males/week.

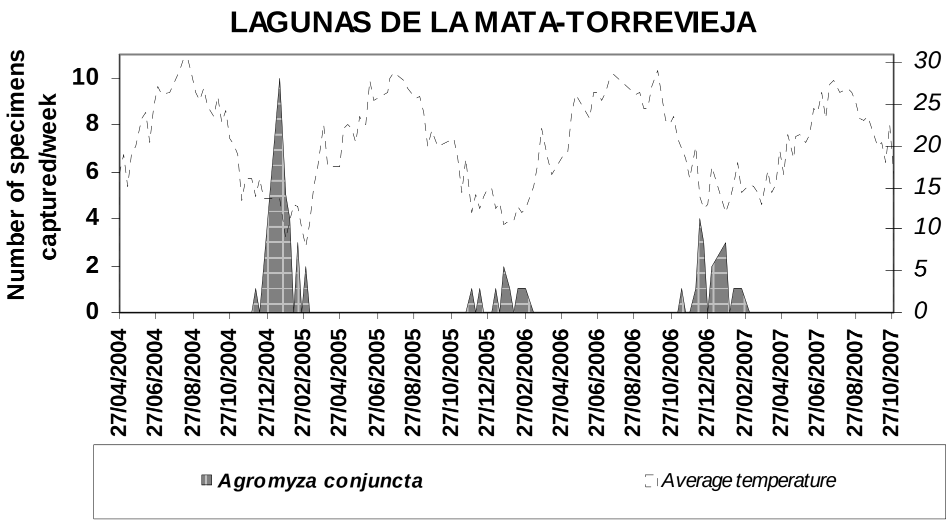


Figure 5-50. Space-time captures evolution of *Agromyza conjuncta* Spencer, 1966 males in Natural Park of “Lagunas de La Mata-Torrevieja”.

Agromyza frontella (Rondani, 1875)

Material examined: <u>Tinença de Benifassà</u>: 2♂, 24.iv.2006-1.v.2006; 1♂, 19-26.vi.2006; <u>Font Roja</u>: 1♂, 20-27.iv.2006.

Diagnostic characters : Small species with reddish frons, 3+1 *dc* and costa ending at vein 4+5. Frons reddish in front, sometimes tending to blackish behind, broad, twice width of eye, conspicuously projecting above eye in profile; orbits generally blackish; jowls deeply extended at rear, up to ½ height of eye; third antennal segment small, black at least on outside, with conspicuous pubescense in male, only a fringe at upper corner in female; first and second segments more reddish; mesonotum with 3+1 strong *dc*, blackish, distinctly shining; legs with femora black, yellow knees, tibiae and tarsi sometimes paler, brownish; wing: length 1.9-2.2 mm, costa ending shortly after vein R_{4+5}, last section of M_{3+4} equal to or slightly longer than penultimate; squamae pale greyish, fringe ochrous to brownish.- Male genitalia as in SPENCER, 1976a: 111.

Distribution: Palaearctic: Austria, Belarus, Britain I., Czech Republic, Danish mainland, European Turkey, French mainland, Germany, Hungary, Italian mainland, Lithuania, Poland, Slovakia, Spanish mainland, Sweden, The Netherlands, Yugoslavia; Near East; Nearctic region.

Host-plants: *Medicago, Melilotus, Trifolium.*

Agromyza frontella is tribe-specific, feeding primarily on *Medicago* but also on *Melilotus*. The genitalia are of similar shape to species on the Vicieae and Genisteae, and the linear-blonch mine is comparable to that of *A. nana* and *A. vicifoliae*.

Phenology: It has been captured between middle and late spring.

Agromyza graminicola Hendel, 1931

Material examined: Lagunas de La Mata-Torrevieja: 1♂, 5-12.ix.2006.

Diagnostic characters: Medium-sized dark species with costa extending to M_{1+2}. Frons dark brown to black, narrow, little more than width of eye, not significantly projecting above eye in profile, orbits scarcely differentiated; orbital bristles short and slender, number varying from 4 to 6; antennae black, third segment enlarged, conspicuosly angular; mesonotum moderately shining black, 4-6 differentiated *dc*, presutural ones small; legs with femora generally entirely black, at most fore-knees somewhat yellowish, tibiae and tarsi slightly paler, brownish; wing length from 2-2.2 mm in male, 2.4-2.6 mm in female, costa extending strongly to vein M_{1+2}, last section of M_{3+4} little more than 1/2 penultimate; veins pale brown; squamae and fringe silvery-white.- Male genitalia as in SPENCER, 1976a: 113.

Distribution: Palaearctic: Austria, Belgium, Britain I., Danish mainland, Estonia, Finland, Germany, Hungary, Lithuania, Poland, Spanish mainland, Sweden.

Host-plants: *Phragmites.*

It has only been recorded mining on the Arundineae family. It is common to be present in Eastern Europe, but it is not known in the west. The linear and little globose mine is typical on *Phragmites communis* Trin.

Phenology: The only male was captured in early September in "Lagunas de La Mata-Torrevieja".

Agromyza intermittens (Becker, 1907)

= *Phytomyza secalina* Hering, 1925

Material examined: Lagunas de La Mata-Torrevieja: 1♂, 30.xi.2004-11.xii.2004; 2♂, 14-21.xii.2004; 10♂, 21.xii.2004-18.i.2005; 5♂, 18-26.i.2005; 4♂, 26.i.2005-2.ii.2005; 3♂, 8-15.ii.2005; 2♂, 22.ii.2005-1.iii.2005; 1♂, 22-29.xi.2005; 1♂, 6-13.xii.2005; 1♂, 3-10.i.2006; 2♂, 17-24.i.2006; 1♂, 24-31.i.2006; 1♂, 7-14.ii.2006; 1♂, 14-21.ii.2006; 1♂, 21-28.ii.2006; 1♂, 7-14.xi.2006; 1♂, 28.xi.2006-5.xii.2006; 4♂, 5-12.xii.2006; 3♂, 12-19.xii.2006; 2♂, 26.xii.2006-2.i.2007; 3♂, 2-24.i.2007; 1♂, 30.i.2007-6.ii.2007; 1♂, 6-13.ii.2007; 1♂, 13-20.ii.2007.

Diagnostic characters: Medium-sized species with reddish, projecting frons and single ors. Frons conspicuosly projecting above eye; 1 *ors* directed upwards and outwards, 3 or 4 slender incurved *ori*; jowls deeply extended at rear; third antennal segments slender, elongate, rounded at end; mouth-margin with broad epistoma. Mesonotum up to 5 *dc* greatly decreasing in size, *acr* in 4 rows. Wing length from 2.3-2.75 mm, costa extending only to vein R_{4+5}, second cross-vein not infrequently lacking or vestigial. Frons orange-red, orbits black; antennae partially pale but third segment largely black; mesonotum mat, greyish-black, legs black but all knees yellow; squamae white, margin darker, fringe white to ochrous. Male genitalia.- Aedeagus as in SPENCER, 1976a: 115.

Distribution: Palaearctic: Belarus, Britain I., Canary Is., Czech Republic, Danish mainland, Estonia, European Turkey, French mainland, Germany, Hungary, Lithuania, Poland, Slovakia, Spanish mainland, The Netherlands, Yugoslavia; East Palaearctic; Near East; North Africa.

Host-plants: *Bromus, Hordeum, Secale.*

Their host-plants families are Bromeae and Triticeae. It is widely present in Europe and in North Africa. This species has been confused with *Agromyza luteitarsis* (Rondani, 1875) but AGUILAR *et al.* (1976), who investigated this species and others attacking cereals in the Paris area, discovered a difference between the colour of the puparia in the two species. *A. intermittens* has uniformly brown puparia, while in *A. luteitarsis* the front segments are blackish.

Phenology: present from the end of autumn until the end of spring in "Lagunas de La Mata-Torrevieja" with 4-5 annual generations. The biggest captures were recorded on 21/12/2004 with average temperatures of 13.8ºC (20ºC max. and 7.5°C min.).

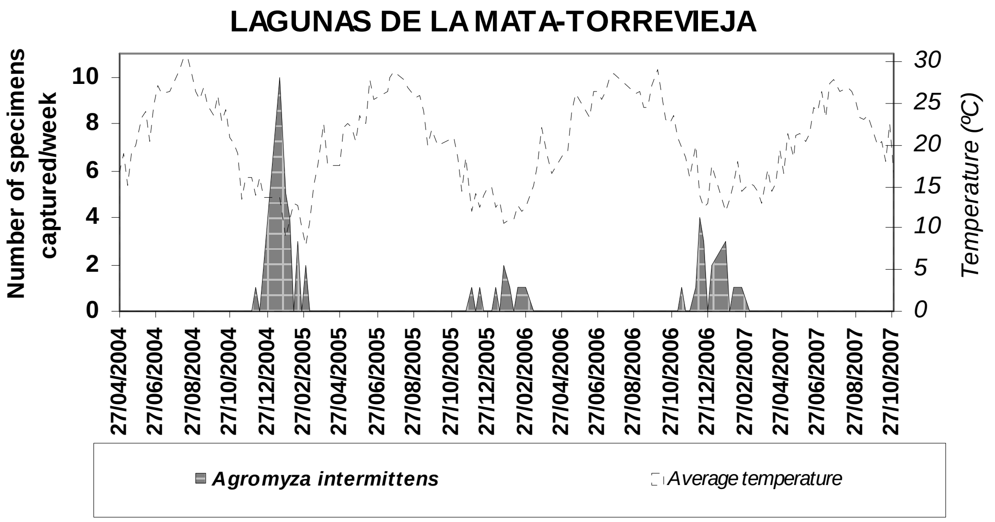


Figure 5-51. Space-time captures evolution of *Agromyza intermittens* (Becker, 1907) males in Natural Park of "Lagunas de La Mata-Torrevieja".

Agromyza johannae de Meijere, 1924

Material examined: <u>Font Roja</u>: 1♂, 13-20.iv.2006.

Diagnostic characters: Frons reddish-brown, distinctly projecting above eye in profile; orbits black; jowls deeply extented at rear; third antennal segment black, at most faintly paler on inside, with only short fringe of pubescence at upper corner in both sexes, first and second segments orange-brown; arista fine, bare, swollen at base; mesonotum with 3+1 strong *dc*, mat, blackish-grey; *acr* in 4 rows; femora almost entirely black, at most fore-knees very slightly yellowish, tibiae and tarsi scarcely paler; wing length 2-2.5 mm, costa extending strongly to vein M_{1+2}, the two sections of M_{3+4} approx. equal, first cross-vein at midpoint of discal cell or slightly basal, squamae and fringe pale, yellowish.- Male genitalia: aedeagus as in SPENCER, 1976a: 116.

Distribution: Palaearctic: Britain I., Crete, Czech Republic, Danish mainland, Dodecanese Is., Estonia, French mainland, Germany, Ireland, Italian mainland, Lithuania, Norwegian mainland, Poland, Sicily, Spanish mainland, Sweden, The Netherlands; Near East.

Host-plants: *Cytisus, Genista, Lupinus, Spartium, Ulex.*

Agromyza johannae genitalia is closest to *Agromyza demeijerei* Hendel, 1920, but first is oligophagous whose normal host is *Cytisus* but which has also been found on *Genista*, *Spartium* and very young leaves of *Ulex*. *A. demeijerei* is monophagous on *Laburnum* sp., forming characteristic blotch mines. Interestingly this species is only known on *Laburnum* cultivated in gardens in Western Europe but is presumably present where the host occurs naturally in Southeastern Europe.

Phenology: It has been captured punctually in the middle of spring.

Agromyza nana Meigen, 1830

= *Dodomyza anthracipes* Rondani, 1875
= *Dodomyza brevinervis* Rondani, 1875
= *Agromyza medicaginis* Robineau-Desvoidy, 1851
= *Agromyza trifolii* Kaltenbach, 1872

Material examined: Tinença de Benifassà: 1♂, 24.iv.2006-1.v.2006; 1♂, 15-22.v.2006; 1♂, 29.v.2006-5.vi.2006; 2♂, 12-23.x.2006; 1♂, 23-30.x.2006; 1♂, 4-11.xii.2006; 1♂, 5-12.ii.2007; 1♂, 20.iii.2007-2.iv.2007; 1♂, 16-23.iv.2007; Lagunas de La Mata-Torrevieja: 1♂, 22.ii.2005-1.iii.2005.

Diagnostic characters: Medium-sized species with reddish frons, mat grey mesonotum and costa ending at vein R_{4+5}. Head: frons broad, twice width of eye, distinctly projecting above eye in profile, reddish; orbits variably darkened; jowls broad, up to 1/3 height of eye; third antennal segment in male thickly covered in long pubescence, in female with a distinct fringe or hairs at upper corner; mesonotum with 3+1 strong *dc*, mat greyish; wing length from 2-2.5 mm, costa ending shortly beyond vein R_{4+5}, last section of M_{3+4} about 1 ½ times as long as penultimate; squamal fringe pale, yellowish-white; legs largely black, fore knees paler.- Male genitalia: aedeagus as in SPENCER, 1976: 125.

Distribution: Palaearctic: Belarus, Britain I., Canary Is., Czech Republic, Danish mainland, Latvia, Lithuania, Malta, Republic of Moldova, Norwegian mainland, Poland, Romania, Sardinia, Sicily, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Ukraine, Yugoslavia; East Palaearctic; Near East; North Africa; Oriental region.

Host-plants: *Anthyllis, Medicago, Melilotus, Onobrychis, Oxalis, Trifolium, Trigonella, Vicia.*

Primary host-plants of *Agromyza nana* appear to be in the Trifolieae where it is found commonly on *Medicago*, *Melilotus*, and *Trifolium*, less frequently on *Trigonella*, with the whitish blotch mine always associated with the midrib. *A. nana* is oligophagous, also found on tribes Hedysareae, Loteae and Vicieae. The male genitalia closely resemble those of *Agromyza frontella* (Rondani, 1875). Interestingly, *A. nana* has managed to extend its range through or round the Himalayas to Delhi and Agra in India where it has been found feeding on *Melilotus*.

Phenology: present from mid winter until late spring in “Tinença de Benifassà”, while in “Lagunas de La Mata-Torrevieja” it has been captured punctually at the beginning of March. 3 generations in spring and 2 in autumn are present, although it is a species that is greatly affected by the weather, because during the drought years of 2004-05 there have been no captures. Maximum temperatures were 2 male captures/week with average temperatures of 17ºC (22ºC max. and 12ºC min.).

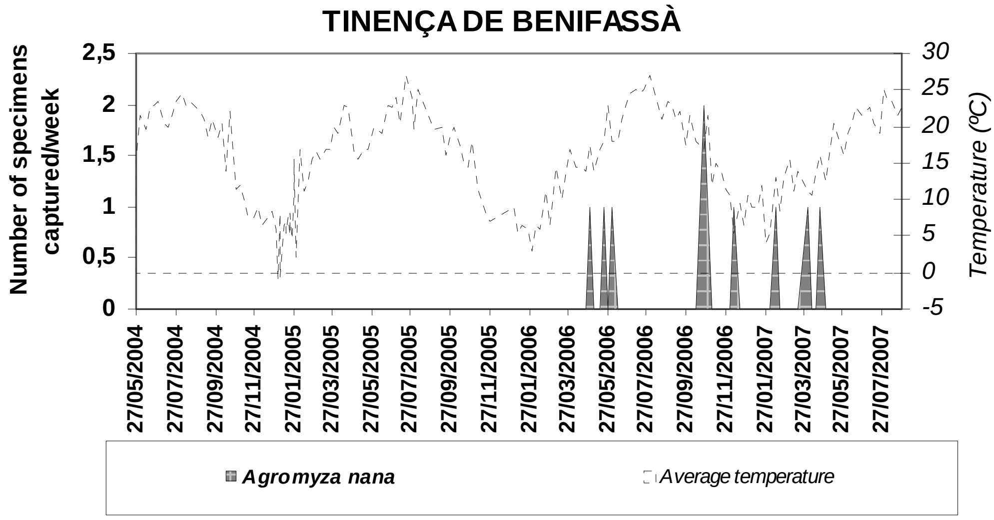


Figure 5-52.- Space-time captures evolution of *Agromyza nana* Meigen, 1830 males in Natural Park of “Lagunas de La Mata-Torrevieja”.

Agromyza nigrescens Hendel, 1920

= *Agromyza heringi* de Meijere, 1925
= *Agromyza japonica* Tsujita, 1951 (As subsp. of *Agromyza nigrescens* Hendel, 1920)
= *Agromyza microchaeta* Hendel, 1920
= *Agromyza oycoviensis* Beiger, 1959

Material examined: Tinença de Benifassà: 3♂, 6-17.iv.2006; 1♂, 17-24.iv.2006; 2♂, 24.iv.2006-1.v.2006; 2♂, 1-8.v.2006; 2♂, 12-23.x.2006; 1♂, 30.x.2006-6.xi.2006; 1♂, 13-20.xi.2006; 1♂, 25.xii.2006-1.i.2007; 1♂, 20.iii.2007-2.iv.2007.

Diagnostic characters: Large black species, with 3+1 *dc*. Frons mat black, conspicuously projecting above eye in profile, orbits weakly shining, appearing paler than frons; jowls broad, deepest at rear, 2/5 height of eye, cheeks forming broad ring below eye; antennal segments black, third round; mesonotum mat, greyish-black, with 3+1 strong *dc*; legs entirely black; wing length from 2.5-3 mm, costa extending to vein M_{1+2}, last section of M_{3+4} 2/3 penultimate; squamae and fringe pale, whitish.- Male genitalia: aedeagus as in SPENCER, 1976a: 129.

Distribution: Palaearctic: Britain I., Canary Is., Czech Republic, Danish mainland, Estonia, Finland, French mainland, Germany, Italian mainland, Lithuania, Malta, Norwegian mainland, Poland, Spanish mainland, Sweden, Switzerland, Yugoslavia; East Palaearctic; Near East.

Host-plants: *Geranium.*

Agromyza nigrescens is a common leaf-miner on *Geranium* in Europe feeding on a number of species, particularly *G. pratense*. A very close species is *A. oycoviensis* mining on *G. phaeum* and *A. japonica* mining on *G. nepalense*, both cited as probably synonyms of *A. nigrescens*.

Phenology: mainly present in spring and autumn when moderate temperatures are present. It has a great fluctuation over the years without having been captured during the 2004-05 period. In 2006, 2 generations in spring and 3 in autumn were presented. The largest captures were 3 males/week with an average temperature of 14.5-17.5ºC.

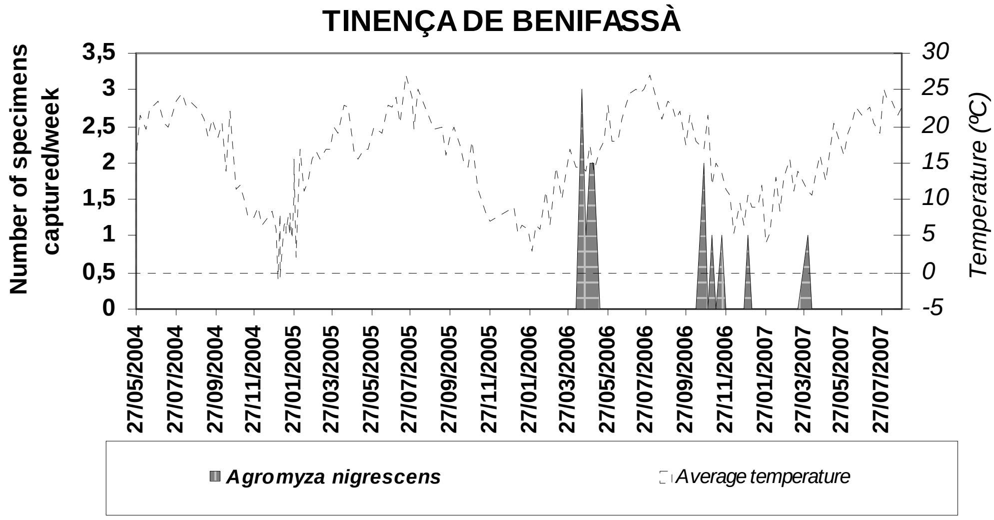


Figure 5-53. Space-time captures evolution of *Agromyza nigrescens* Hendel, 1920 males in Natural Park of "Lagunas de La Mata-Torrevieja".

Agromyza rondensis Strobl, 1900 (Possibly a junior synonym of *A. obscuritarsis* Rondani, 1875)

= *Agromyza nigrifemur* Hendel, 1931
= *Domonyza ocellaris* Hendel, 1920
= *Agromyza veris* Hering, 1951

Material examined: Tinença de Benifassà: 1♂, 18-25.ix.2006; 1♂, 2-12.x.2006; Lagunas de La Mata-Torrevieja: 1♂, 16-23.xi.2004; 2♂, 7-14.xii.2004; 1♂, 14-21.xii.2004; 6♂, 21.xii.2004-18.i.2005; 2♂, 26.i.2005-2.ii.2005; 1♂, 8-15.ii.2005; 2♂, 22.ii.2005-1.iii.2005; 1♂, 20-27.ix.2005; 1♂, 8-15.xi.2005; 2♂, 15-22.xi.2005; 3♂, 29.xi.2005-2.xii.2005; 1♂, 6-13.xii.2005; 1♂, 13-20.xii.2005; 2♂, 20-27.xii.2005; 1♂, 3-10.i.2006; 1♂, 17-24.i.2006; 2♂, 24-31.i.2006; 1♂, 31.i.2006-7.ii.2006; 2♂, 14-21.ii.2006; 1♂, 21-28.ii.2006; 4♂, 31.x.2006-7.xi.2006; 5♂, 7-14.xi.2006; 8♂, 14-21.xi.2006; 5♂, 21-28.xi.2006; 1♂, 28.xi.2006-5.xii.2006; 7♂, 5-12.xii.2006; 6♂, 5-

12.xii.2006; 9♂, 19-26.xii.2006; 6♂, 26.xii.2006-2.i.2007; 8♂, 2-24.i.2007; 1♂, 6-13.ii.2007; 3♂, 13-20.ii.2007; 2♂, 20.ii.2007-6.iii.2007; 1♂, 10-17.iv.2007.

Diagnostic characters: Medium-sized species, with brown frons, elongate third antennal segment and pale squamal fringe; costa ending at vein R_{4+5}. Frons broadly projecting above eye, particularly in front, jowls deeply extended at rear, third antennal segment conspicuously elongate. Mesonotum with 3+2 *dc*, decreasing in size substantially but the two pre-sutural bristles still relatively long; acrostichals irregularly in three rows in front, two only behind. Wing length from 1.75 mm in male to 3 mm in female, costa ending at vein R_{4+5}, last and penultimate sections of M_{3+4} approximately equal but last may be somewhat longer or shorter. Frons colour distinctly brownish, hind-margin of head and orbits black; mesonotum conspicuously grey, mat; squamal fringe white. Male genitalia.- Aedeagus as in SPENCER, 1976a: 140.

Distribution: Palaearctic: Austria, Balearic Is., Belarus, Belgium, Britain I., Canary Is., Crete, Croatia, Czech Republic, Dodecanese Is., Estonia, European Turkey, French mainland, Germany, Hungary, Italian mainland, Lithuania, Norwegian mainland, Poland, Romania, Sicily, Slovakia, Spanish mainland, Sweden, Yugoslavia; Near East; Oriental region.

Host-plants: *Arrhenatherum, Avena, Brachypodium, Bromus, Calamagrostis, Dactylis, Hordeum, Oryzopsis, Poa, Secale, Sorghum, Triticum.*

Their hosts are present in Avenae, Bromeae, Poeae and Triticeae. It is widespread from Spain to Sweden. Its male genitalia shows a close relationship with *Agromyza conjuncta* Spencer, 1966 which is most common in Southern Europe but has also been recorded in Scotland.

Phenology: present in "Tinença de Benifassà" in autumn. In "Lagunas de La Mata-Torrevieja" is largely present basically with moderate temperatures in autumn and winter. The number of generations present high variability with at least 5, since late October to mid-March to late April. The highest captures were recorded in December 2006 with an average temperature of 17.5ºC.

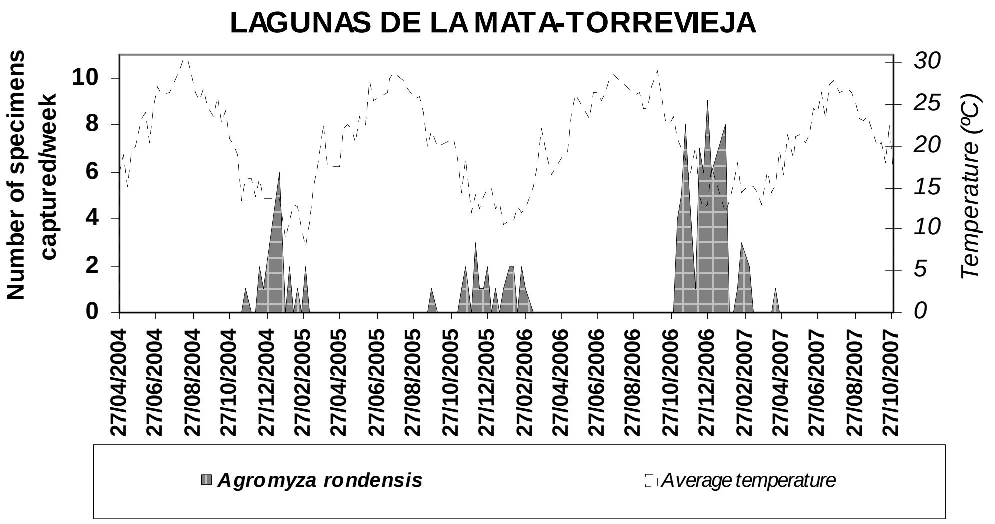


Figure 5-54. Space-time captures evolution of *Agromyza rondensis* Strobl, 1900 males in Natural Park of "Lagunas de La Mata-Torrevieja".

5.3.1.2 Genus ***Melanagromyza*** Hendel, 1920

Melanagromyza genus is composed of 51 species at Palaearctic region level. MARTINEZ (2004) cites the presence of 34 species in Europe. In continental Spain the biodiversity of this genus is until now composed of 13 species, adding *Melanagromyza ferulae* Spencer, 1966 (CERNY & MERZ, 2006). In the present thesis is added the presence in Spain of *Melanagromyza eupatorii* Spencer, 1957, *Melanagromyza nibletti* Spencer, 1957, *Melanagromyza sojae* (Zehnter, 1900) and *Melanagromyza spinulosa* Spencer, 1974.

Diagnostic characters: sub-costa well developed and joining vein R_1; normally only 2 pairs of strong *dc* (rarely 3), presutural *dc* always lacking; costa extending to M_{1+2}, second cross-vein always present; head with all antennal segments and legs black; halteres black or dark brown. Mesonotum normally largely black with varying greenish colouration and the abdomen is normally more conspicuously shining green or bluish. All species are stout and frecuently large, with wing length up to 3.5 mm (SPENCER, 1972; SPENCER, 1976a). The male genitalia has a basiphallus U-shaped and a complex formed by the mesophallus-distiphallus forming a complex in which appears the mesophallus ventrally as a bladder. The distiphallus presents a symmetrical appearance, and sometimes with elongated central tubule. The sperm sac is usually wide and black (ECHEVARRÍA, 1996).

Melanagromyza species are mainly internal stem-borers, but other species have been described as *Melanagromyza symphyti* Griffiths, 1963 undermining thick-leaf stalks, species such as *Melanagromyza cunctans* (Meigen, 1830) forming stem-galls on *Lotus*, or other species undermining seed heads.

Melanagromyza genus is characterized by having a wide range of hosts undermining 23 botanical families: Acanthaceae, Amaranthaceae, Araliaceae, Avicenniaceae, Boraginaceae, Bromeliaceae, Capparidaceae, Chenopodiaceae, Compositae, Convolvulaceae, Crassulaceae, Cruciferae, Euphorbiaceae, Leguminosae, Malvaceae, Orchidaceae, Pedaliaceae, Ranunculaceae, Scrophulariaceae, Solanaceae, Umbelliferae, Urticaceae, Verbenaceae (BENAVENT-CORAI *et al.*, 2005a).

Melanagromyza genus is a morphologically very close to *Ophiomyia*, *Japanagromyza* and *Hexomyza*. In fact many species such as *Ophiomyia beckeri* (Hendel, 1923), *O. cunctata* (Hendel, 1920), *O. orbiculata* (Hendel, 1931) and *O. pulicaria* (Meigen, 1830) were initially referred to as *Melanagromyza*. Both genus have similar eating behaviours, and share many families of host-plants (Acanthaceae, Verbenaceae, Chenopodiaceae, Compositae, Cruciferae, Euphorbiaceae, Leguminosae, Malvaceae, Ranunculaceae, Scrophulariaceae, Solanaceae, Umbelliferae and Amaranthaceae) (BENAVENT-CORAI *et al.*, 2005). During the global phenological study of these genera it is thought to be desirable to study them together, because a lot species into *Ophiomyia* genus can not readily be distinguished from *Melanagromyza* on external characters, and it is especially easy to introduce errors in the diagnosis of females. In Natural Parks only captures belonging to *Melanagromyza* and *Ophiomyia* were obtained, suggesting an overlapped space-time evolution.

In “Tinença de Benifassà” Natural Park the phenology of *Melanagromyza* and *Ophiomyia* have an evolution trend very dependent on the weather. It is established between 4-5 generations uninterrupted since from March to late September. Female populations often exceed those of males almost every year, at times meaning populations of these genera are practically composed of females. The biggest captures have occurred from late May to mid July with maximum temperatures averaging 46-32 males-females/week with average temperatures varying between 23-24.5ºC. These are species that in the presence of host-plants are enhanced with relatively high temperatures (Fig. 5-55).

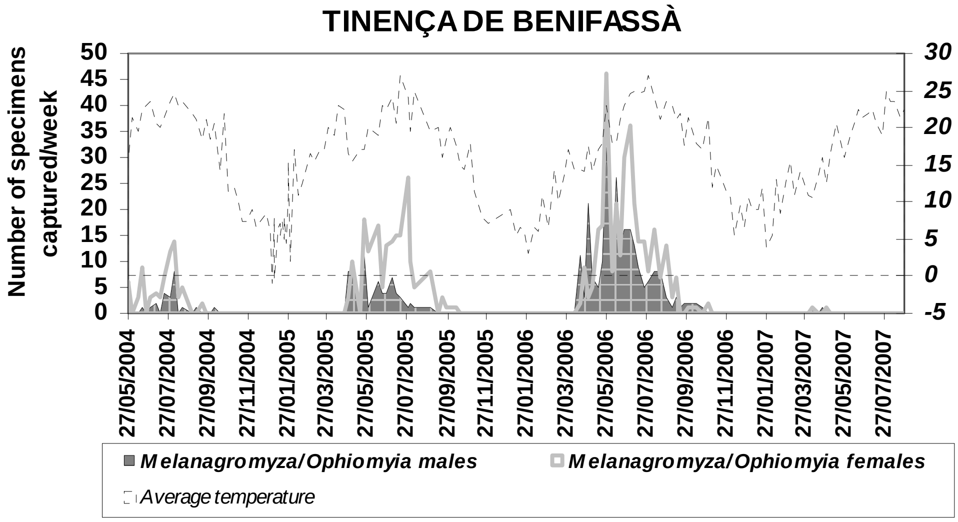


Figure 5-55. Space-time captures evolution of males and females of *Melanagromyza*/*Ophiomyia* genera in Natural Park of "Tinença de Benifassà".

"Font Roja" populations are much lower, presumably by the different botanical composition of this park. Periods of *Melanagromyza* and *Ophiomyia* presence are the same as in "Tinença de Benifassà". Also tend to dominate the female presence with maximum captures of 17 females-males/week during the month of July with average temperatures of 23-24ºC (Fig. 5-56).

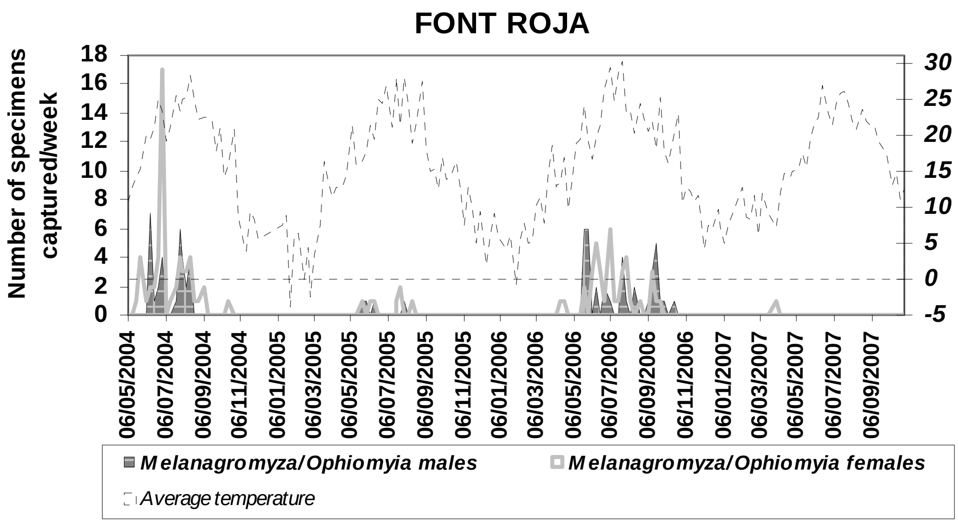


Figure 5-56. Space-time captures evolution of males and females of *Melanagromyza*/*Ophiomyia* genera in Natural Park of "Font Roja".

In “Lagunas de La Mata-Torrevieja” evolution captures were similar to “Font Roja”, being only in 2004 in which there have been significant captures composed mainly of females. Although captures have been generally very low (<5 flies/week) during the year 2004 the female populations have managed to exceed 40 flies/week. The highest captures were recorded from 8-15/06/2004 with average temperatures of 20.5ºC (Fig. 5-57).

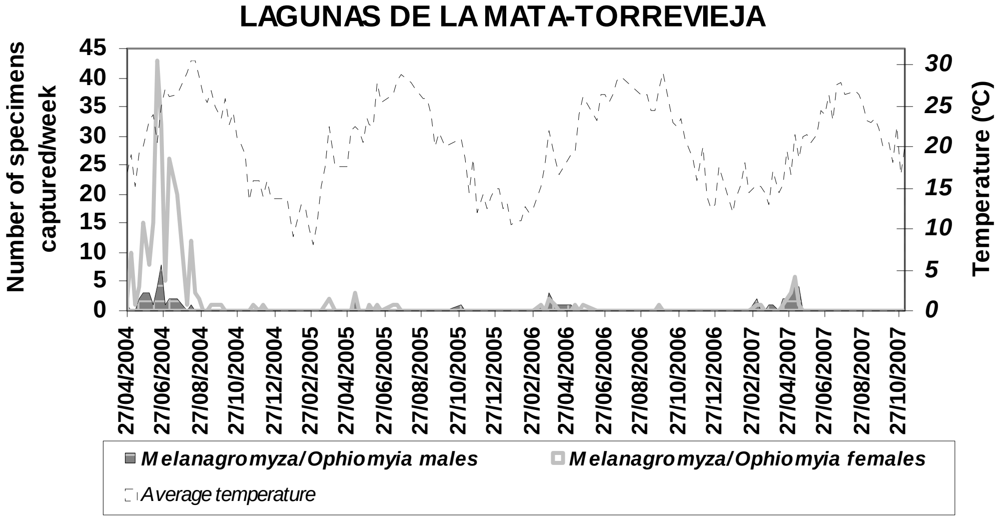


Figure 5-57. Space-time captures evolution of males and females of *Melanagromyza*/*Ophiomyia* genera in Natural Park of “Lagunas de La Mata-Torrevieja”.

Melanagromyza albocilia Hendel, 1931

= *Melanagromyza convolvuli* Spencer, 1971

Material examined: Tinença de Benifassà: 1♂, 10-17.vi.2004; 2♂, 15-22.vii.2004; 2♂, 22-29.vii.2004; 6♂, 29.vii.2004-5.viii.2004; 1♂, 12-19.viii.2004; 1♂, 2-9.ix.2004; 1♂, 30.ix.2004-7.x.2004; 2♂, 16-23.v.2005; 1♂, 23-30.v.2005; 4♂, 6-13.vi.2005; 2♂, 13-20.vi.2005; 3♂, 20-27.vi.2005; 1♂, 1-8.v.2006; 4♂, 8-15.v.2006; 3♂, 15-22.v.2006; 5♂, 22-29.v.2006; 5♂, 5-12.vi.2006; 5♂, 12-19.vi.2006; 3♂, 19-26.vi.2006; 3♂, 3-10.vii.2006; 2♂, 10-17.vii.2006; 2♂, 17-24.vii.2006; 3♂, 24.vii.2006-1.viii.2006; 2♂, 1-10.viii.2006.

Diagnostic characters: Small greenish-black species. Frons 1 ½ times width of eye, not significantly projecting above eye in profile; 2 *ors* and 2 *ori*, orbital setulae sparse, in single row, reclinate; ocellar triangle only weakly shining; jowls relatively broad, ¼ vertical height of eye; eye in male slightly pilose; third antennal segment and arista virtually bare; mesonotum shining blackish-greenish, abdomen largely green; wing length from 2.1 mm in male to 2.5 mm in female; squamae and fringe white.- Male genitalia as in SPENCER, 1976a: 46.

Distribution: Palaearctic: Austria, Britain I., Canary I., Czech Republic, Danish mainland, French mainland, Germany, Hungary, Lithuania, Poland, Slovakia, Spanish mainland, Sweden; Near East; Oriental region.

Host-plants: *Convolvulus.*

Two closely-related internal stem-borers are known on *Convolvulus arvensis* L. *Melanagromyza albocilia* was described from Austria and its external morphology is very similar to *Melanagromyza convolvuli* Spencer, 1971. Their distinction is only possible throughout the study of their genitalia.

Phenology: It is present in "Tinença de Benifassà" from Spring to the beginning of autumn. Biggest captures have not exceeded 6 males/week, having average temperatures close to 25ºC which have favoured maximum captures (Fig. 5-58).

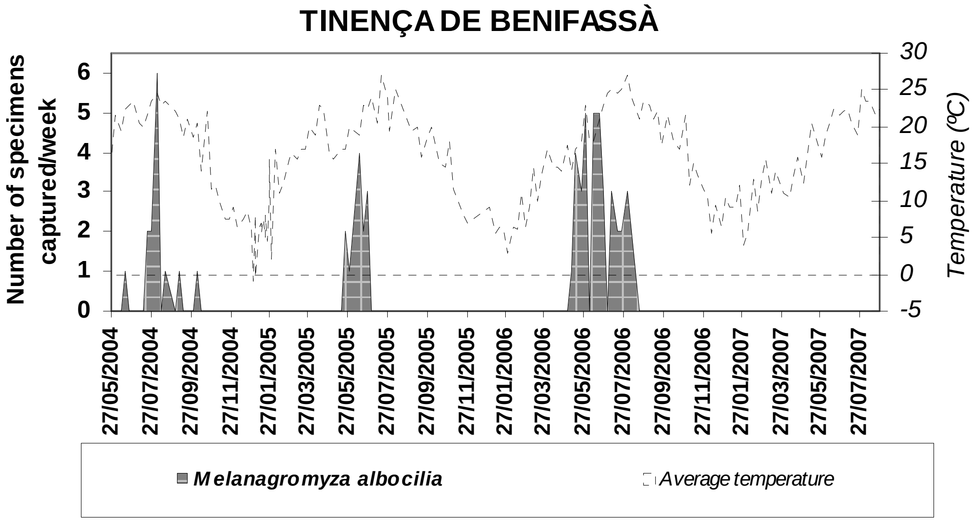


Figure 5-58. Space-time captures evolution of *Melanagromyza albocilia* Hendel, 1931 males in Natural Park of "Tinença de Benifassà".

Melanagromyza fabae Spencer, 1973

Material examined: Tinença de Benifassà: 1♂, 19-26.vi.2006.

Diagnostic characters: Medium-sized species, with proclinate orbital setulae and black squamal fringe. Frons 1 ½ times width of eye, slightly projecting above eye in profile; 2 strong *ors*, 3 or 4 largely incurved *ori*; orbital setulae numerous, entirely proclinate; eye with white pubescense at level of *ors*; jowls deepest in centre below eye, ¼ height of eye, cheeks linear; third antennal segment small, round, arista virtually bare. Mesonotum with 2 strong *dc*, acrostichals in some 10 rows in front, extending in 4 or 5 rows to level of first *dc*. Wing length from 2.6-2.7 mm in male to 3.2 mm in female, last section of vein M_{3+4} two-thirds length of penultimate, first cross-vein slightly beyond midpoint of discal cell. Frons colour mat black, ocellar triangle and orbits scarcely shining; mesonotum mat, almost greyish-black viewed from front, weakly shining black from behind; abdomen weakly shining, greenish; squamae grey, margin and fringe black; halteres black. Male genitalia.- Aedeagus as in SPENCER, 1973: 42, cylindrical bladder below mesophallus curving upwards behind and extending slightly beyond rear of mesophallus.

Distribution: Palaearctic: Britain I., Germany, Spanish mainland.

Host-plants: *Vicia.*

Melanagromyza fabae is known only on *Vicia faba* L. in England where the larva feeds and pupates within the root. The male genitalia are distinctive but typical on the genus. In china, Gansu province, *Melanagromyza viciae* Wenn, 1985 was also reared from stems of *V. faba*. The genitalia suggests a close relationship to *M. fabae*.

Phenology: It has been found punctually in “Tinença de Benifassà” at the end of June.

Melanagromyza verbasci Spencer, 1957

Material examined: <u>Tinença de Benifassà</u>: 2♂, 29.iv.2005-6.v.2005; 3♂, 16-23.v.2005.

Diagnostic characters: SPENCER, 1957: 188.

Distribution: Palaearctic: Czech Republic, Germany, Lithuania, Spanish mainland; North Africa.

Host-plants: *Verbascum.*

Verbascum is only mined in Europe for two Agromyzidae species, *Melanagromyza verbasci* Spencer, 1957 and *Amauromyza (Cephalomyza) verbasci* (Bouché, 1847). The first was discovered feeding in stems of *Verbascum phlomoides* L. in Western Germany. The male genitalia is characteristic of many species in the genus and the posterior spiracles of the puparium are also typical of the genus but are distinctive. The second, *A. (Cephalomyza) verbasci*, forms large blotch mines primarily on *Verbascum* but also on *Scrophularia*, and interestingly also on *Buddleja*.

Phenology: It is present in “Tinença de Benifassà” at the end spring.

5.3.1.3 Genus ***Ophiomyia*** Bražnikov, 1897

Ophiomyia genus is composed of 76 species at Palaearctic region level. In continental Spain, the presence of 19 species is cited (MARTINEZ, 2004), although later it was updated until 22 species (CERNY, 2006; CERNY & MERZ, 2006). In the present thesis is added the occurrence of *Ophiomyia labiatarum* Hering, 1937 and *Ophiomyia penicillata* Hendel, 1920.

Diagnostic characters: Uniformly black species, without any metallic colouration even of the abdomen, and both halteres and the squamal fringe are usually black. The raised facial keel and male vibrissal fasciculus are present in the great majority of species. The orbital setulae are normally uniformly reclinate, but it can be also proclinate. There are normally 2 strong dorso-central bristles, but it can be 3 in some species. In most species the costa extends to vein M_{1+2} but in several it can end at R_{4+5} (SPENCER, 1976a).

Most Western European species are easily recognizable by the distinct facial keel dividing the base of antennae, by the forwardly projecting jowls in both sexes, and in the male, by the conspicuous vibrissal fasciculus. Coloration is uniformly black, without any trace of metallic sheen on either mesonotum or abdomen. There are only 2 pairs of *dc*, and wing venation is as in *Melanagromyza*. However a lot species for example the *pulicaria* group, external characters dividing *Ophiomyia* and *Melanagromyza* largely disappear and the correct affiliation is only detectable from the male genitalia. In most *Ophiomyia* species the distal section of the aedeagus is highly asymmetrical and the basiphallus are characteristically elongate (SPENCER, 1972b)

It is considered more evolutionarily advanced than the genus *Melanagromyza*, as well as stem-miners there are also species capable of undermining leaves. Relatively few host-plants are known by the difficulty of detecting mines. The presence of *Ophiomyia* species is known in 24 families, Acanthaceae, Amaranthaceae, Asparagaceae, Campanulaceae, Caryophyllaceae, Chenopodiaceae, Compositae, Cruciferae, Dipsacaceae, Euphorbiaceae, Gentianaceae, Goodeniaceae, Hemerocallidaceae, Labiatae, Leguminosae, Malvaceae, Ranunculaceae, Rubiaceae, Scrophulariaceae, Solanaceae, Umbelliferae, Valerianaceae and Verbenaceae.

Ophiomyia beckeri (Hendel, 1923)

= *Melanagromyza euphorbiae* Hendel, 1923
= *Melanagromyza goniaea* Hendel, 1931

Material examined: <u>Tinença de Benifassà</u>: 1♂, 15-22.vii.2004; 1♂, 22-29.vii.2004; 2♂, 22-29.iv.2005; 1♂, 20-27.vi.2005; 1♂, 27.vi.2005-4.vii.2005; 1♂, 28.vii.2005-1.viii.2005; 11♂, 6-17.iv.2006; 9♂, 17-24.iv.2006; 18♂, 24.iv.2006-1.v.2006; 6♂, 1-8.v.2006; 3♂, 15-22.v.2006; 16♂, 22-29.v.2006; 6♂, 29.v.2006-5.vi.2006; 13♂, 5-12.vi.2006; 5♂, 12-19.vi.2006; 5♂, 19-26.vi.2006; 2♂, 26.vi.2006-3.vii.2006; 4♂, 3-10.vii.2006; 3♂, 17-24.vii.2006; 2♂, 24.vii.2006-1.viii.2006; 5♂, 1-10.viii.2006; 7♂, 10-20.viii.2006; 6♂, 20-28.viii.2006; 1♂, 11-18.ix.2006; 5♂, 25.ix.2006-2.x.2006; 2♂, 2-12.x.2006; 1♂, 12-23.x.2006; 1♂, 2-9.iv.2007; 1♂, 16-23.iv.2007; <u>Font Roja</u>: 5♂, 3-10.vi.2004; 2♂, 17-24.vi.2004; 4♂, 24.vi.2004-1.vii.2004; 1♂, 8-15.vii.2004; 1♂, 15-22.vii.2004; 3♂, 22-29.vii.2004; 2♂, 29.vii.2004-2.viii.2004; 1♂, 2-9.viii.2004; 3♂, 9-16.viii.2004; 1♂, 6-13.vi.2005; 1♂, 25.vii.2005-1.viii.2005; 4♂, 15-22.v.2006; 5♂, 22-29.v.2006; 2♂, 5-12.vi.2006; 1♂, 19-26.vi.2006; 1♂, 17-25.vii.2006; 1♂, 25-31.vii.2006; 1♂, 7-14.viii.2006; 1♂, 28.viii.2006-4.ix.2006; 3♂, 4-11.ix.2006; 3♂, 11-18.ix.2006; 1♂, 18-25.ix.2006; 1♂, 25.ix.2006-2.x.2006; 1♂, 9-16.x.2006; <u>Lagunas de La Mata-Torrevieja</u>: 1♂, 20-27.iv.2004; 2♂, 11-18.v.2004; 3♂, 18-25.v.2004; 3♂, 25.v.2004-1.vi.2004; 1♂, 1-8.vi.2004; 4♂, 8-15.vi.2004; 5♂, 15-22.vi.2004; 1♂, 29.vi.2004-6.vii.2004; 1♂, 25-31.v.2005; 1♂, 4.x.2005-1.xi.2005; 1♂, 28.ii.2006-14.iii.2006; 3♂, 21-28.iii.2006; 1♂, 28.iii.2006-4.iv.2006; 1♂, 11.iv.2006-2.v.2006; 1♂, 19.ix.2006-26.ix.2006; 2♂, 20.ii.2007-6.iii.2007; 1♂, 20-27.iii.2007; 1♂, 27.iii.2007-3.iv.2007; 2♂, 10-17.iv.2007; 2♂, 17-24.iv.2007; 3♂, 24.iv.2007-1.v.2007; 4♂, 1-8.v.2007; 3♂, 8-16.v.2007.

Diagnostic characters: Frons not projecting above eye, orbital setulae short, mainly reclinate, a few above proclinate; jowls deepest in front, 1/5-1/6 vertical height of eye, vibrissa normal; wing length up to 2.5 mm, costa extending to vein M_{1+2}, last section of vein M_{3+4} distinctly shorter than penultimate; colour: entirely black, mesonotum shining.- Male genitalia: aedeagus as in SPENCER, 1976a: 61.

Distribution: Palaearctic: Austria, Balearic Is., Britain I., Canary Is., Czech Republic, Danish mainland, Finland, French mainland, Germany, Ireland, Lithuania, Madeira,

Poland, Sicily, Spanish mainland, Yugoslavia; Afro-tropical region; Near East; North Africa; Oriental region.
Host-plants: *Coreopsis, Crepis, Launaea, Leontodon, Sonchus, Taraxacum.*

Ophiomyia beckeri belongs to the primitive *Ophiomyia* group 1 established by Spencer (1990), and it is a polyphagous species that share a lot hosts with other close species like *Ophiomyia cunctata* (Hendel, 1920) and *Ophiomyia pulicaria* (Meigen, 1830). All larvae of cited species feeding within the midrib, with short offshoots into the leaf blade. *Ophiomyia nasuta* (Melander, 1913) mining on *Taraxacum* and *Ophiomyia pinguis* (Fallén, 1820) on *Cichorium* and *Leontodon* can be closely associated with this group. *O. beckeri* is particularly common in the Cape area, South Africa on *Sonchus*.

Phenology: It is present in all three Natural Parks studied. In "Tinença de Benifassà" and in "Font Roja" they are continuously present from spring to the end of autumn when average the temperatures range is 17.5-24.2ºC. In "Lagunas de La Mata-Torrevieja", *Ophiomyia beckeri* is present practically throughout all seasons except when higher or colder temperatures are present (>35ºC and <5ºC, respectively).

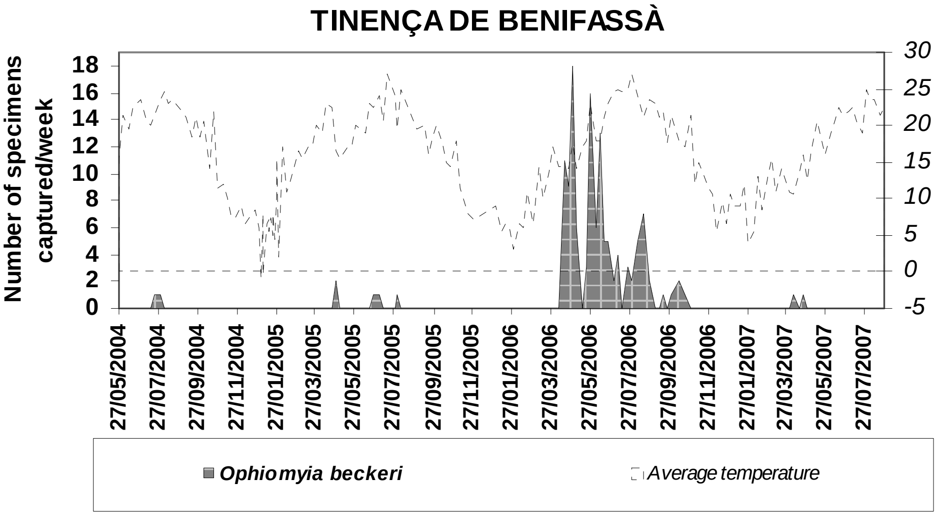


Figure 5-59. Space-time captures evolution of *Ophiomyia beckeri* (Hendel, 1923) males in Natural Park of "Tinença de Benifassà".

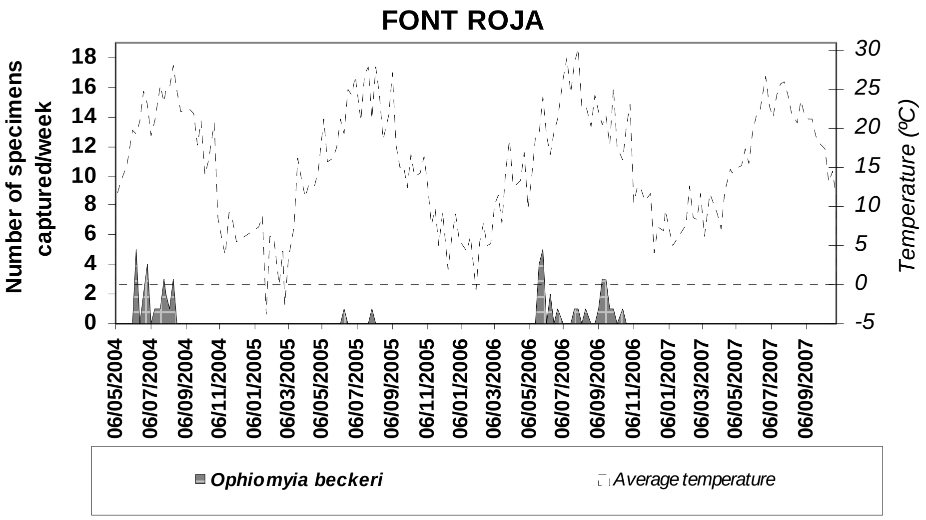


Figure 5-60. Space-time captures evolution of *Ophiomyia beckeri* (Hendel,1923) males in Natural Park of “Font Roja”.

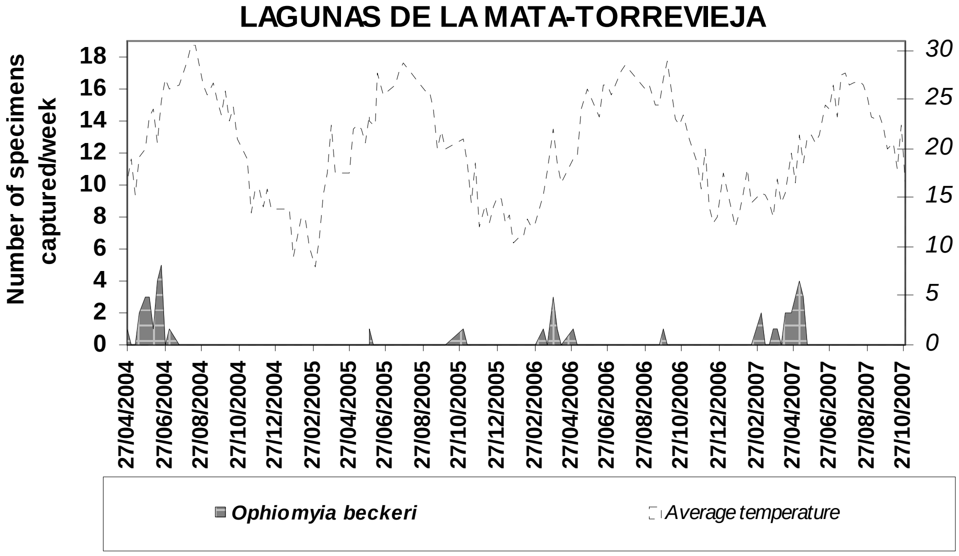


Figure 5-61. Space-time captures evolution of *Ophiomyia beckeri* (Hendel, 1923) males in Natural Park of “Lagunas de La Mata-Torrevieja”.

Ophiomyia ononidis Spencer, 1966

Material examined: Tinença de Benifassà: 1♂, 25.vi.2004-1.vii.2004; 1♂, 15-22.vii.2004; 1♂, 6-13.vi.2005; 1♂, 25.vi.2005-4.vii.2005; 1♂, 27.vi.2005-4.vii.2005; 3♂, 4-11.vii.2005; 1♂, 11-18.vii.2005; 4♂, 22-29.v.2006; 5♂, 19-26.vi.2006; 3♂, 26.vi.2006-3.vii.2006; 4♂, 3-10.vii.2006; 1♂, 10-17.vii.2006; 1♂, 25.ix.2006-2.x.2006; Font Roja: 1♂, 22-29.vii.2004; 1♂, 29.vii.2004-2.viii.2004; Lagunas de La Mata-Torrevieja: 3♂, 15-22.vi.2004; 2♂, 6-20.vii.2004; 1♂, 3-10.viii.2004; 2♂, 3-10.v.2005; 1♂, 8-16.v.2007.

Diagnostic characters: SPENCER**,** 1966a: 52.

Distribution: Palaearctic: Britain I., Czech Republic, Germany, Lithuania, Spanish mainland.

Host-Plants: *Ononis, Medicago.*

Ophiomyia ononidis feeds exclusively on *Ononis* spp., forming an external stem mine. The adult closely resembles *Ophiomyia curvipalpis* (Zetterstedt 1848), an oligophagous feeder on Asteraceae, and the two cannot be separated by external characters. Differences between the two species are clearly reflected in the genitalia and also in larval characters, with the posterior spiracles in *O. ononidis* having 6-7 pores on each process, while *O. curvipalpis* retains the plesiomorphous state.

Phenology: It is present in all three Natural Parks studied, basically in spring and summer. Maximum captures were produced in “Tinença de Benifassà” with 5 males/week when average temperatures oscillate around 23ºC.

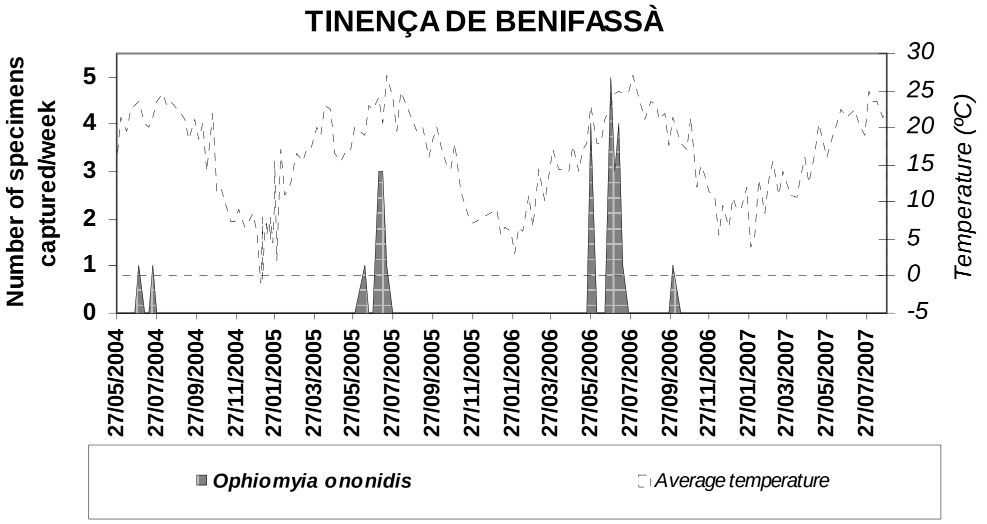


Figure 5-62. Space-time captures evolution of *Ophiomyia ononidis* Spencer, 1966 males in Natural Park of "Tinença de Benifassà".

Ophiomyia orbiculata (Hendel, 1931)

= *Melanagromyza cagliostro* Rohdendorf-Homanova, 1958
= *Melanagromyza hexachaeta* Hendel, 1931
= *Melanagromyza nostradamus* Hering, 1933
= *Melanagromyza paracelsus* Hering, 1933

Material examined: Tinença de Benifassà: 1♂, 1-8.vii.2004; 1♂, 29.vii.2004-5.viii.2004; 1♂, 24.iv.2006-1.v.2006; 2♂, 15-22.v.2006; 1♂, 22-29.v.2006; 2♂, 19-26.vi.2006; 1♂, 10-17.vii.2006; 1♂, 24.vii.2006-1.viii.2006; 1♂, 1-10.viii.2006; 1♂, 6-11.ix.2006.

Diagnostic characters: Frons broad, 1 ½ to 2 times width of eye, distinctly raised and orbits visible above eye; normally 2 *ors* and 2 *ori* but sometimes a third bristle present probably representing an additional *ori*; orbital setulae reclinate; jowls broad, up to ¼ height of eye, cheeks forming distinct ring below eye; male without vibrissal fasciculus; bases of antennae adjoining, not divided by a raised facial keel; mesonotum moderately shining black, with 2 strong, normal *dc* and frequently either one strong additional one or 2 or 3 smaller ones between the second and the suture; wing length 2-2.5 mm, costa extending strongly to vein M_{1+2}, last section of M_{3+4} normally slightly shorter than penultimate; squamae grey, margin and fringe black.- Male genitalia: aedeagus as in SPENCER, 1976a: 73; aberrant distiphallus bowl-shaped, fringed with some 12 minute spinules.

Distribution: Palaearctic: Austria, Belarus, Britain I., Czech Republic, Danish mainland, European Turkey, Finland, French mainland, Germany, Hungary, Lithuania, Norwegian mainland, Poland, Slovakia, Spanish mainland, Sweden, Switzerland, Yugoslavia.

Host-Plants: *Lathyrus, Pisum.*

The only *Ophiomyia* species known in the Vicieae tribe is *O. orbiculata* that appears to be strictly host-specific on *Pisum*. The larva behaviour is feeding on the stem and pupating in the lower stem or root. The genitalia suggests a close relationship with the Old World tropical species *Ophiomyia centrosematis* (de Meijère, 1940) but the pupal spiracles with 17-22 bulbs suggest possible relationship with *Ophiomyia heracleivora* Spencer, 1957 on *Heracleum*.

Phenology: It is present in "Tinença de Benifassà" from spring until autumn. It presents a great seasonality captures over the years, being 2006 in which the highest number was recorded the highest number. Generally, low weekly captures of 1-2 males/week were obtained with average temperatures ranging from 17.5-24.5ºC.

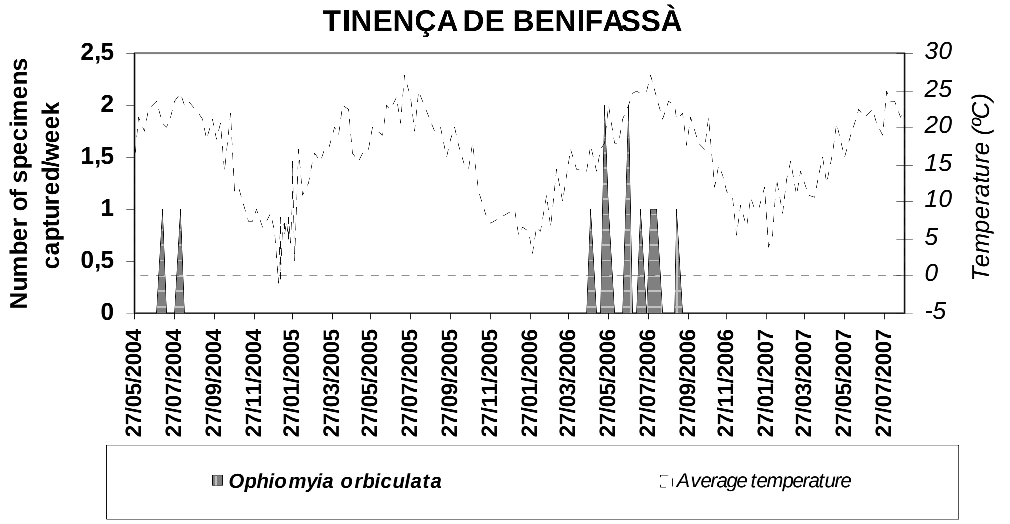


Figure 5-63. Space-time captures evolution of *Ophiomyia orbiculata* (Hendel, 1931) males in Natural Park of "Tinença de Benifassà".

Ophiomyia vitiosa Spencer, 1964

Material examined: Tinença de Benifassà: 1♂, 13-20.vi.2005; 1♂, 18-28.vii.2005; 2♂, 22.v.2006-29.v.2006; 1♂, 29.v.2006-5.vi.2006; 5♂, 5-12.vi.2006; 1♂, 12-19.vi.2006; 1♂, 26.vi.2006-3.vii.2006; 1♂, 3-10.vii.2006; 1♂, 10-20.viii.2006; 1♂, 20-28.viii.2006.

Diagnostic characters: SPENCER, 1964: 806.

Distribution: Palaearctic: Austria, Czech Republic, Hungary, Lithuania, Spanish mainland.

Host-plants: *Linaria*.

Synonymous of *Phytobia alliariae* Hering, 1954 suspected by von-TSCHIRNHAUS within the catalogue of German Agromyzidae.

Phenology: Captures were produced in "Tinença de Benifassà" primarily during 2006. Maximum captures were 5 males/week with an average temperature of 18ºC (25ºC max. and 11ºC min.).

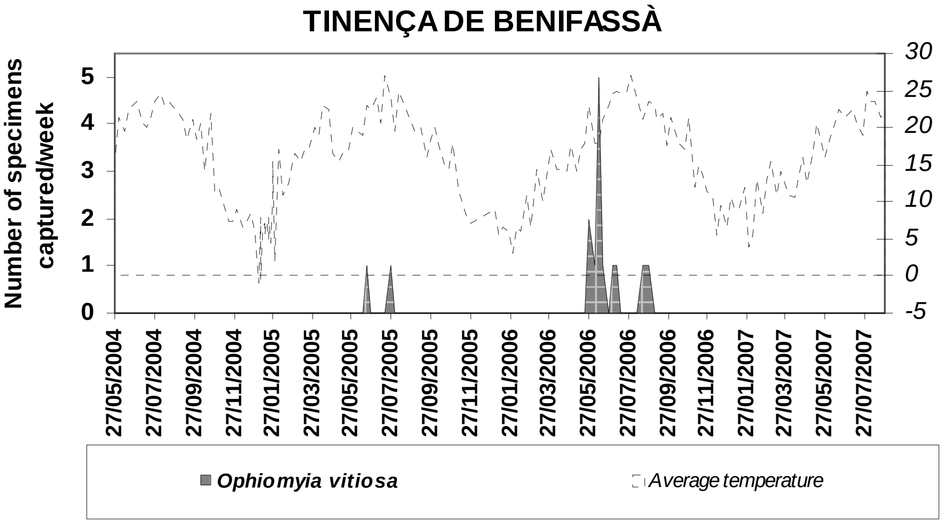


Figure 5-64. Space-time captures evolution of *Ophiomyia vitiosa* Spencer, 1964 males in Natural Park of "Tinença de Benifassà".

5.3.2 Subfamily *Phytomyzinae*

5.3.2.1 Genus ***Amauromyza*** **Hendel, 1931**

Amauromyza genus comprises 29 species in the Palaearctic region. MARTINEZ (2004) cites the presence of 21 species in Europe and 11 in continental Spain. In the latter should be added *Amauromyza (Cephalomyza) karli* (Hendel, 1927) and *Amauromyza (Cephalomyza) luteiceps* (Hendel, 1920) (CERNY & MERZ, 2006), being composed the continental Spanish fauna by 13 species. This genus is divided in two subgenera: *Amauromyza* Hendel, 1931 and *Cephalomyza* Hendel, 1931.

Key diagnostic characters: Orbits normal, separated throughout by the frons; orbital setulae erect, reclinate or absent; wing costa extending to apex of vein M_{1+2}; scutellum dark concolorous with mesonotum; halteres with knob black; if yellow, subgenus *Cephalomyza* presenting a distiphallus with numerous spinules. *Trilobomyza* genera presents some distinctly characters: halteres with knob white or yellow; vein M_{1+2} ending nearest wing tip; scutellum and lunule distinctly different to *Cerodontha*; only mid-tibia sometimes with lateral bristle, fore-tibia never; orbits in same plane as frons; frons yellow; pre-sutural *dc* present; and antennae and legs black (SPENCER, 1976a). Male genitalia.- Ejaculatory apodeme with enlarged, bowl-shaped base (SASAKAWA, 1961, SPENCER, 1976a, SPENCER, 1990) that can be considered as apomorphy. The epandrium is long, from lateral view apically tapering, the surstyli is not articulated and located distinctly below the tip of epandrium. Bacilliform sclerites are usually elongated (DEMPEWOLF, 2004).

Species in this genus are either leaf-miners forming a distinctive blotch or internal stem-borers. The stem-borers are all in the subgenus *Cephalomyza* but this also includes some blotch-miners (SPENCER, 1972b).

Known host-plants belonging to *Amauromyza* mine on 12 families of plants: Amaranthaceae, Bignoniaceae, Buddlejaceae, Campanulaceae, Caryophyllaceae, Chenopodiaceae, Compositae, Elaeagnaceae, Iridaceae, Labiatae, Polygonaceae and Scrophulariaceae.

Amauromyza (Amauromyza) morionella (Zetterstedt, 1848)

= *Agromyza novakii* Strobl, 1902

Material examined: Font Roja: 1♂, 29.iii.2006-6.iv.2006.

Distribution: Palaearctic: Britain I., Corsica, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Hungary, Italian mainland, Norwegian mainland, Poland, Romania, Sardinia, Sicily, Spanish mainland, Sweden, Yugoslavia; North Africa (doubtful).

Diagnostic characters: Small, entirely dark species. Frons largely black, possibly dark brown centrally and above, broad, almost twice width of eye, distinctly projecting above eye; orbits strongly differentiated, slightly shining; 2 *ors* and 2 *ori*, all equal, the *ori* largely incurved; orbital setulae minute or absent; jowls broad, slightly more than ¼ height of eye, cheeks forming distinct ring below eye; mesonotum with 3 post-sutural *dc*, pre-sutural normally not differenciated, if detectable, little longer than *acr*; pleura shining black; wing length 1.7-2.1 mm, costa extending to vein M_{1+2}, last section of M_{3+4} twice length of penultimate; legs and halteres black.- Male genitalia: aedeagus as in SPENCER, 1976a: 159; ninth sternite with broadly rounded side-arms.

Host-plants: *Ballota, Marrubium.*

Amauromyza (Amauromyza) morionella is not distinguishable on external characters from *Amauromyza (Amauromyza) leonuri* Spencer, 1971, only the male genitalia reveal they are two different species. It is closely related to *Amauromyza (Amauromyza) balcanica* (Hendel, 1931), known from Spain, Greece and Iran, with *Phlomis* as its only confirmed host. The genitalia differs only in detail from *A. (Am.) morionella*.

Phenology: It has been captured on time at the beginning of spring in “Font Roja”.

Amauromyza (Cephalomyza) monfalconensis (Strobl, 1909)

Material examined: Tinença de Benifassà: 1♂, 22-29.v.2006.

Diagnostic characters: Frons black or dark brown, twice width of eye, conspicuously raised above eye in profile; 2 *ors* and 3 or 4 *ori*, orbital setulae sparse, reclinate; jowls deeply extended at rear, up to ½ height of eye; cheeks forming broad ring below eye; third antennal segment slightly longer than broad, rounded at end, arista finely pubescent; mesonotum distinctly mat, slatey-black, with 3+1 strong *dc*, the second, third or fourth approx. equal, *acr* short, irregularly in 4 rows; wing length 2.1 to 2.75 mm, costa extending to vein M_{1+2}, last section of M_{3+4} 1 ½ times penultimate; legs entirely black; squamae grey, margin and fringe black, halteres entirely yellow.- Male genitalia: aedeagus as in SPENCER, 1976a: 161, with distiphallus surrounded by spinulose membrane.

Distribution: Palaearctic: Austria, Britain I., Czech Republic, Danish mainland, Estonia, French mainland, Germany, Hungary, Italian mainland, Lithuania, Poland, Romania, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia.

Host-plants: *Rumex.*

Amauromyza (Cephalomyza) monfalconensis occurs widely throughout Europe and its host has been discovered as *Rumex* sp., the larva feeding internally in the stem. The genitalia show that this species is closely related to the three species feeding in stems of *Amaranthus*, *Atriplex* and *Chenopodium*. It can be accepted that the four species are derived from a single ancestor on the Caryophyllales. Other related species are known as stem-borers, including *Amauromyza (Cephalomyza) madrilena* Spencer, 1957 on *Phlomis* (Family: Lamiaceae).

Phenology: It has been captured punctually at the end of May.

Amauromyza (Cephalomyza) karli (Hendel, 1927)

Material examined: <u>Tinença de Benifassà</u>: 1♂, 16-23.v.2005; 1♂, 23-30.v.2005; 1♂, 16-23.v.2005; 1♂, 4.vii.2005-11.vii.2005; 1♂, 19-26.ix.2005; 1♂, 22-29.v.2006; 1♂, 29.v.2006-5.vi.2006; 1♂, 10-17.vii.2006; 1♂, 17-24.vii.2006; 1♂, 10-20.viii.2006.

Diagnostic characters: HENDEL, 1927: 253.- Male genitalia: aedeagus as in Figure 5-65.

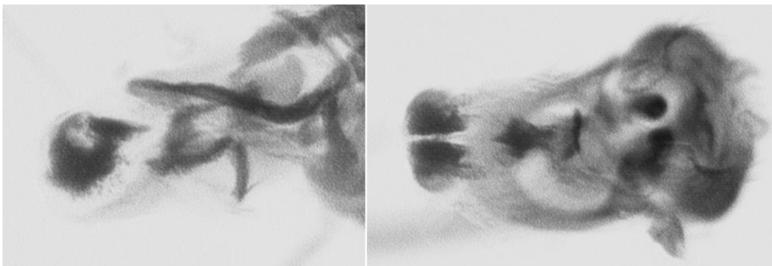


Figure 5-65. Aedeagus male genitalia in side and ventral positions (design by R. GIL-ORTIZ).

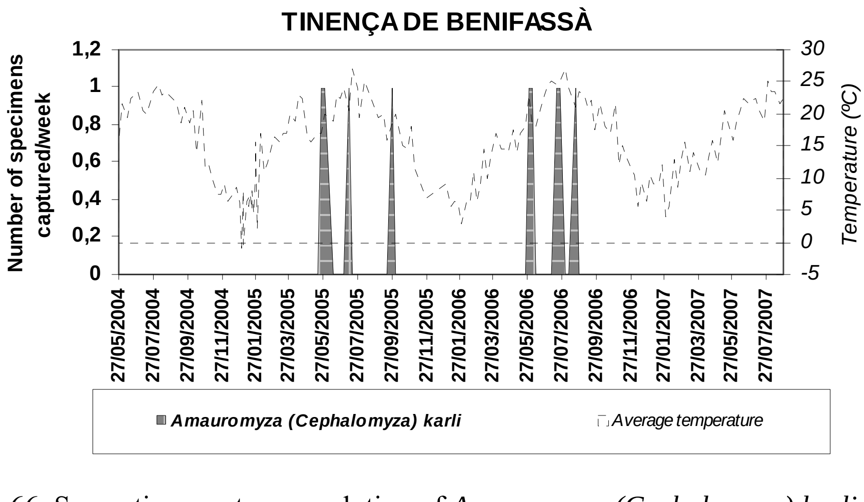


Figure 5-66. Space-time captures evolution of *Amauromyza (Cephalomyza) karli* (Hendel, 1927) males in Natural Park of "Tinença de Benifassà".

Distribution: Czech Republic, French mainland, Germany, Hungary, Poland; Nearctic region.

Host-plants: Unknown

Phenology: It is present in "Tinença de Benifassà" in spring and summer. Highest captures were only 1 male/week with average temperatures between 17-20.5°C.

5.3.2.2 Genus ***Aulagromyza*** Enderlein, 1936

Aulagromyza genus in the Palaearctic region is composed of 42 species. The European known fauna is established in 32 species and 7 in the continental Spain (MARTINEZ, 2004). In this thesis are cited four new records: *Aulagromyza buhri* (de Meijere, 1938), *Aulagromyza luteoscutellata* (de Meijere, 1924), *Aulagromyza similis* (Brischke, 1880) and *Aulagromyza trivittata* (Loew, 1873).

This genus was separated of *Phytomyza* by the different arrangement of the orbital setulae, which are here reclinate, upright or lacking (always distinctly proclinate in *Phytomyza*). The costa always ends at R_{4+5} and the second cross-vein may be present or lacking. HENDEL (1920) erected the genus *Phytagromyza* for this group, with *Domomyza flavocingulata* (Strobl, 1909) as type of the genus. However, it has since been shown that *flavocingulata* is in no way related to the other species in the group and correctly belongs to *Cerodontha*. At present this genus is named *Aulagromyza*.

Key diagnostic characters: Orbits normal, separated throughout by the frons; orbital setulae erect, reclinate or absent; costa ending only to R_{4+5}; pro-thoracic bristle present; and third antennal segment round (SPENCER, 1976b).

The larvae feed as leaf-miners or external stem-miners in 10 botanical families, Asclepiadaceae, Caprifoliaceae, Compositae, Cruciferae, Dipsacaceae, Leguminosae, Oleaceae, Rosaceae, Rubiaceae and Salicaceae (BENAVENT-CORAI *et al.*, 2005).

Aulagromyza orphana **(Hendel, 1920)**

Material examined: <u>Tinença de Benifassà</u>: 1♂, 22-29.iv.2005; 4♂, 29.iv.2005-6.v.2005; 2♂, 16-23.v.2005; 9♂, 6-17.iv.2006; 11♂, 17-24.iv.2006; 14♂, 24.iv.2006-1.v.2006; 1♂, 1-8.v.2006; 1♂, 8-15.v.2006; 1♂, 20.iii.2007-2.iv.2007; 5♂, 16-23.iv.2007; 1♂, 23-30.iv.2007.

Diagnostic characters: Head with 2 *ors* and 2 *ori*; orbital setulae normally completely lacking, if present, minute; jowls conspicuously rounded, shining black along lower margin; third antennal segment small, round; proboscis conspicuously elongate; normally only 2 developed *dc*, weak third sometimes present; wing tip midway between veins R_{4+5} and M_{1+2}, second cross-vein present, last section of M_{3+4} slightly over twice length of penultimate; colour: frons and jowls orange-yellow, orbits darkened; face and all antennal segments black; mesonotum and scutellum shining black; sides of thorax black; legs black, with only fore-knees distinctly yellow; squamae yellowish-grey, margin and fringe black.- Male genitalia: aedeagus as in SPENCER, 1976b: 319.

Distribution: Palaearctic: Austria, Britain I., Czech Republic, Danish mainland, European Turkey, French mainland, Germany, Hungary, Ireland, Poland, Slovakia, Spanish mainland, The Netherlands.

Host-plants: *Galium.*

Aulagromyza orphana genitalia is very close to *Aulagromyza buhri* (de Meijere, 1938) but more strongly pigmented. This is more common than *Aulagromyza lucens* (de Meijere, 1924) and with the same primary host, it seems probable that there is some difference in the larval feeding of the two species but this remains to be clarified.

Phenology: It is present broadly in spring in "Tinença de Benifassà". Maximum captures were 14 males/week with average temperatures of 17.5ºC (21ºC max. and 14ºC min.) (Fig. 5-67).

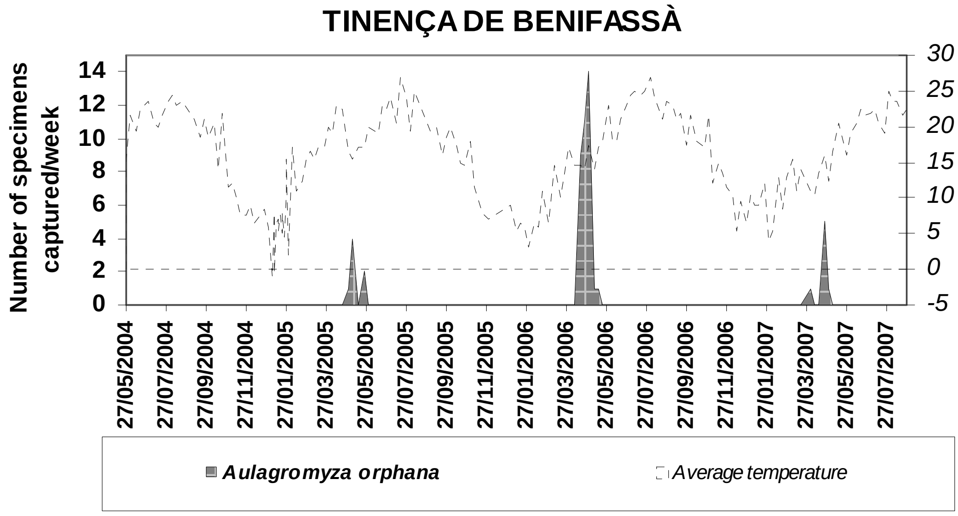


Figure 5-67. Space-time captures evolution of *Aulagromyza orphana* (Hendel, 1920) males in Natural Park of "Tinença de Benifassà".

5.3.2.3 Genus ***Calycomyza*** Hendel, 1931

Calycomyza genus is composed in the Palaearctic region by 8 species. MARTINEZ (2004) cites the presence of 5 species in Europe; and 3 in Spain, *Calycomyza artemisiae* (Kaltenbach, 1856), *Calycomyza flavomaculata* (Spencer, 1960) and *Calycomyza humeralis* (von Roser, 1840).

Key diagnostic characters: orbital normal, separated throughout by the frons; orbital setulae erect, reclinate, or absent; wing costa extending only to apex of vein M_{1+2}; scutellum dark, concolorous with mesonotum; halteres with knob white or yellow; vein 1+2 ending nearest wing tip; scutellum and lunule distinctly differents to *Cerodontha*; only mid-tibia sometimes with lateral bristle, foretibia never; stridulating mechanism in male lacking; orbits in same plane as frons, frons yellow; no pre-sutural *dc*; mesopleura and femora largely black; inner hind margin of epandrium with patch of strong bristles (SPENCER, 1976b).

Known botanical families mined by *Calycomyza* are the following: Bignoniaceae, Boraginaceae, Compositae, Convolvulaceae, Labiatae, Leguminosae, Malvaceae, Papaveraceae, Polygonaceae, Tiliaceae, Umbelliferae, Verbenaceae (BENAVENT-CORAI *et al.*, 2005). As far as were aware all species in this genus are leaf-miners (SPENCER, 1972b).

Calycomyza humeralis (von Roser, 1840)

= *Agromyza atripes* Brischke, 1880
= *Agromyza bellidis* Kaltenbach, 1873

Material examined: Tinença de Benifassà: 2♂, 16-23.v.2005; 1♂, 13-20.vi.2005; 1♂, 20-27.vi.2005; 1♂, 22-29.v.2006; 1♂, 5-12.vi.2006; 1♂, 12-19.vi.2006; Lagunas de La Mata-Torrevieja: 1♂, 7-14.xi.2006; 1♂, 28.xi.2006-5.xii.2006; 1♂, 3-10.iv.2007; 1♂, 10-17.iv.2007.

Diagnostic characters: Frons bright yellow, narrow, little wider than eye, distinctly projecting above eye in profile; 2 reclinate *ors*, 2 incurved *ori*, orbital setulae sparse, reclinate; upper orbits broadly black to upper *ors*, frecuently very narrowly black adjoining eye margin; jowls yellow, broad, 1/3 height of eye, cheeks forming distinct ring below; antennae black, third segment large, ovoid, with distinct angle at upper corner; face grey; mesonotum shining black, with 3+0 *dc*, *acr* in 4 rows between *dc*; mesopleura largely black, yellow at upper hind-corner, notopleural area and rear of humerus bright yellow; legs almost entirely black, though fore-knees can be indistinctly yellowish; scutellum black; wing length 2-2.35 mm, costa extending to vein M_{1+2}, last section of M_{3+4} long, 2-2 ½ times length of penultimate; squamae and fringe white.- Male genitalia: aedeagus as in SPENCER, 1976b: 307; lower corner of epandrium with conspicuous path of bristles.

Distribution: Palaearctic: Albania, Austria, Belgium, Britain I., Corsica, Czech Republic, Danish mainland, European Turkey, French mainland, Germany, Hungary, Italian mainland, Norwegian mainland, Poland, Romania, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; Afro-tropical region; Australian region; East Palaearctic; Nearctic region; Neotropical region; Oriental region.

Host-plants: *Aster, Bellis, Bellium, Callistephus, Conyza, Erigeron, Haplopappus, Helianthus, Heterotecha, Hysterionica, Madia, Solidago, Tithonia, Zinnia.*

Calycomyza humeralis is common on the Asteraceae, where it has been recorded on ten genera, and it is also known on the Heliantheae and Madieae. A distinctive character of the species is the angulate third antennal segment, and the larval posterior spiracles are unusual, with up to ten pores, of which four are elongate, finger-like, and the others shorter, more curving. The genitalia are of a form present in a number of species found mainly on Asteraceae but also on Lamiaceae. *C. humeralis* is greatly extended, although this species was described in Europe, it occurs throughout the New World, in Africa, India to Papua New Guinea and Australia, including Lord Howe Island.

Phenology: It is present at the beginning of summer in “Tinença de Benifassà”. The most favorable period are the months of May and June with average temperatures between 17-22.5ºC and maximum temperatures of 22-30ºC (Fig. 5-68). In “Lagunas de

La Mata-Torrevieja" captures were obtained in April with average temperatures of 15ºC (19ºC max.), and in November with an average temperatures of 19.9ºC (25ºC max.) (Fig. 5-69). The highest captures have not exceeded 2 males/week in any case.

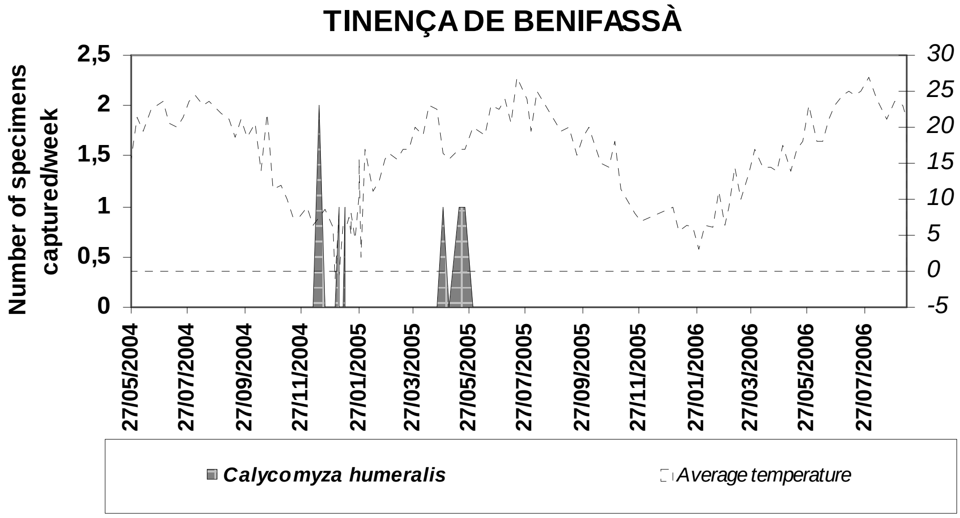


Figure 5-68. Space-time captures evolution of *Calycomyza humeralis* (von Roser, 1840) males in Natural Park of "Tinença de Benifassà".

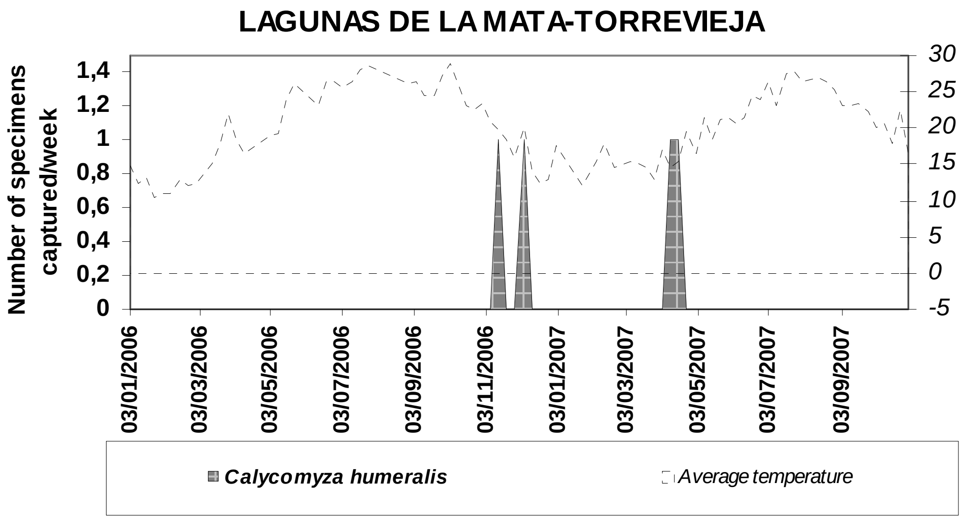


Figure 5-69. Space-time captures evolution of *Calycomyza humeralis* (von Roser, 1840) males in Natural Park of "Lagunas de La Mata-Torrevieja".

5.3.2.4 Genus ***Cerodontha*** Rondani, 1961

Genus *Cerodontha* has been divided into seven subgenera: *Icteromyza* Hendel, 1931; *Cerodontha* Rondani, 1861; *Xenophytomyza* Frey, 1946; *Poemyza* Hendel, 1931; *Phytagromyza* Hendel, 1920; *Butomomyza* Nowakowski, 1967 and *Dizygomyza* Hendel, 1920. *Cerodontha* genus is composed of 138 species in the Palaearctic region. European *Cerodontha* composition is 122 species and the continental Spanish 23 (MARTINEZ, 2004). Later, CERNY & MERZ (2006) cited the presence of *Cerodontha (Dizigomyza) fasciata* (Strobl, 1880) and *Cerodontha (Xenophytomyza) atronitens* (Hendel, 1920). In the present thesis is cited a new record: *Cerodontha (Poemyza) lapplandica* (Rydén, 1956). The subgenera composition of continental Spanish species is *Cerodontha* (23%), *Dizygomyza* (23%), *Icteromyza* (15%), *Poemyza* (38%) and *Xenophytomyza* (1%).

Key diagnostic characters: Sub-costa well developed throughout its length, coalescing with R_1 before reaching the costa; orbits normal, separated throughout by the frons; orbital setulae erect, reclinate or absent; wing costa extending to apex of vein M_{1+2}; if only to R_{4+5}, the lunule higher than semicircle; scutellum dark, concolorous with mesonotum; halteres with knob white or yellow; vein M_{1+2} ending nearest wing tip; scutellum with only 2 bristles, third antennal segment with a spine or projection or at least angulate; or lunule conspicuously higher than a semicircle, either narrow or triangular; or lunule semicircular and third antennal segment in male enlarged.

Icteromyza species are recognizable by the large, normally yellowish lunule and the extended ocellar triangle; in *Xenophytomyza* there are only 2 scutellar bristles and their adults are entirely black; *Poemyza* is characterised by the high, narrow lunule. In *Dizygomyza* the lunule is broad and approximately semicircular and in the male in most species the third antennal segment is greatly enlarged and covered with thick pubescence; the lunule of *Butomomyza* species is intermediate between that of *Poemyza* and *Dizygomyza*, the third antennal segment is always small and, in the male genitalia, the surstyli bear a group of short, strong spines on the inner corner (SPENCER, 1976a).

The larvae of this genus feed exclusively on Monocotyledoneae. Botanical composition of families mined by *Cerodontha* is Cyperaceae, Gramineae, Iridaceae, Juncaceae and Typhaceae. The family with the highest representation of genera mined is Graminae. All species feed either as leaf-miners or in *Icteromyza*, *Cerodontha* and *Xenophytomyza* in the leaf-sheath or even in the stem.

Cerodontha (Cerodontha) denticornis (Panzer, 1806)

= *Agromyza acuticornis* Meigen, 1830
= *Agromyza confinis* Meigen, 1830
= *Cerodontha ghooma* Singh & Ipe, 1973
= *Cerodontha lacustris* Garg, 1971
= *Chlorops meigenii* Fallén, 1823
= *Cerodontha narkandae* Singh & Ipe, 1973
= *Agromyza nigritarsis* Meigen, 1830
= *Ceratomyza nigriventris* Strobl, 1900 As subsp. of *C. denticornis* (Panzer).
= *Ceratoomyza nigroscutellata* Strobl, 1900 As subsp. of *C. denticornis* (Panzer).
= *Ceratomyza semivittata* Strobl, 1909
= *Agromyza tarsella* Zetterstedt, 1848
= *Cerodontha teestae* Singh & Ipe, 1973

Material examined: Tinença de Benifassà: 1♂, 3-10.vi.2004; 1♂, 10-17.vi.2004; 1♂, 25.vi.2004-1.vii.2004; 1♂, 6-13.vi.2005; 1♂, 11-18.vii.2005; 1♂, 15-22.v.2006; 2♂, 22-29.v.2006; 2♂, 29.v.2006-5.vi.2006; 2♂, 5-12.vi.2006; Font Roja: 1♂, 10-17.vi.2004; 1♂, 3-10.vii.2006; Lagunas de La Mata-Torrevieja: 2♂, 4-11.v.2004; 2♂, 11-18.v.2004; 11♂, 25.v.2004-1.vi.2004; 4♂, 1-8.vi.2004; 2♂, 8-15.vi.2004; 1♂, 29.vi.2004-6.vii.2004; 2♂, 14-21.xii.2004; 1♂, 21.xii.2004-18.i.2005; 1♂, 10-17.v.2005; 1♂, 22-29.xi.2005.

Diagnostic characters: Frons distinctly projecting above eye near base of antennae; 2 strong *ors*, 1 weaker *ori*, the *ors* nearer eye margin than the *ori*; third antennal segment elongate with short spine at upper corner; 3+1 strong *dc*, *acr* regularly in 2 rows; wing length from 1.9 mm in male to 2.5 mm in female, last and penultimate sections of M_{3+4} approx. equal; colour: frons, jowls, face, palps, first and second antennal segments bright yellow, third segment black; orbits generally black or at least faintly brownish around base of *ors*; mesonotum mat, greyish-black, or yellow centrally and adjoining scutellum, entirely without *acr*; scutellum either black or variably yellow; mesopleura black or variably yellow; abdomen entirely black or tergites yellow-bordered and sometimes also yellow laterally.- Male genitalia: aedeagus as in SPENCER, 1976a: 179.

Distribution: Palaearctic: Austria, Azores, Belgium, Britain I., Bulgaria, Canary Is., Channel Is., Czech Republic, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Greek mainland, Hungary, Ireland, Italian mainland, Lithuania, Madeira, Norwegian mainland, Poland, Sicily, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; East Palaearctic; Near East; North Africa; Oriental region.

Host-plants: *Agropyron, Alopecurus, Arundo, Calamagrostis, Dactylis, Festuca, Holcus, Hordeum, Lolium, Phalaris, Phleum, Poa, Secale, Triticum.*

It is present in 13 genera in tribes Aveneae, Poeae and Triticeae. Very common in Europe, extending to North Africa, and also present in Japan. The third antennal segment has a characteristic spine present in most species in the subgenus but replaced by an angular projection in others. Other important characteristics is *acr* lacking. The male genitalia is very similar to most species in the subgenus.

Phenology: It is present in the three Natural Parks studied basically in summer and also at the end of autumn in "Lagunas de La Mata-Torrevieja". Overall captures have been low with high annual fluctuations. A maximum of 11 males/week has been recorded in the Natural Park of "Lagunas de La Mata-Torrevieja" with average temperatures of 23.2ºC (26ºC max. and 20.5ºC min.) (Fig. 5-70). In "Tinença de Benifassà" captures did not exceed 2 males/week, with average temperatures comprising between 18-23ºC, being maximum temperatures below 30ºC (Fig. 5-71). In "Font Roja" the low captures were produced in summer with average temperatures of 25ºC.

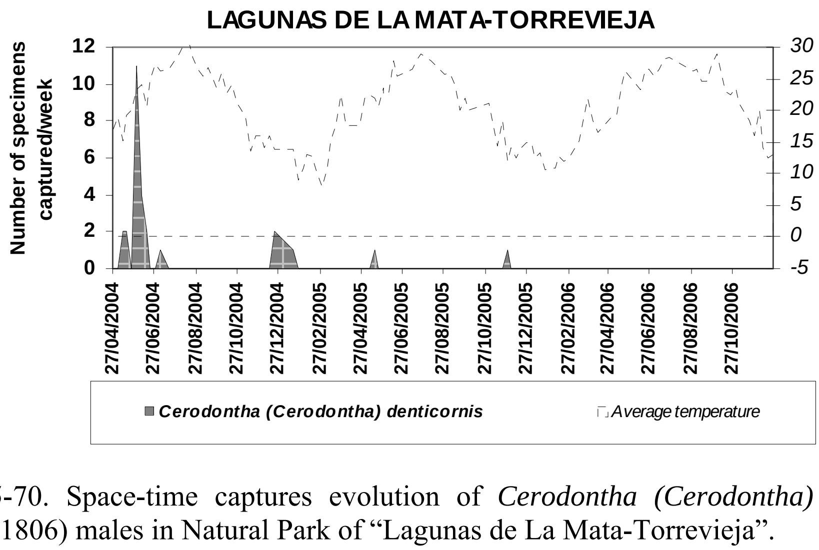


Figure 5-70. Space-time captures evolution of *Cerodontha (Cerodontha) denticornis* (Panzer, 1806) males in Natural Park of "Lagunas de La Mata-Torrevieja".

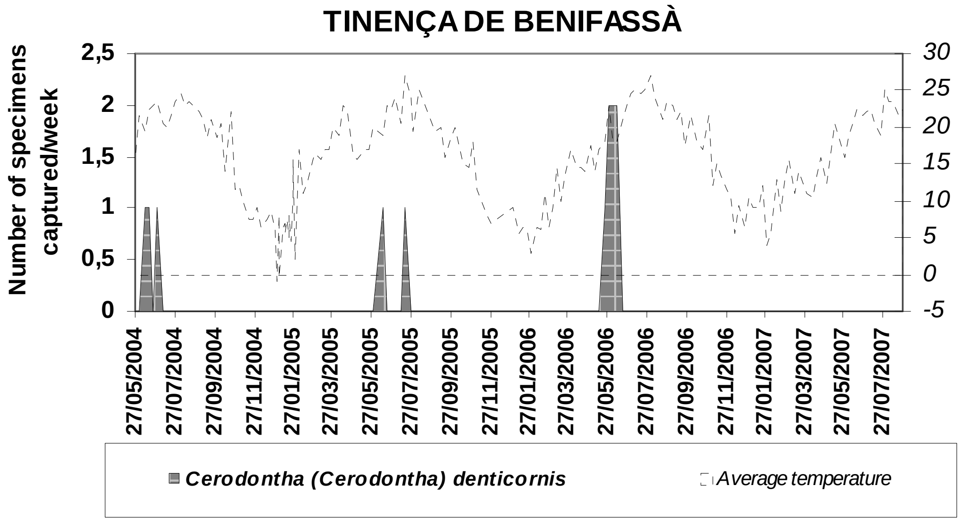


Figure 5-71. Space-time captures evolution of *Cerodontha (Cerodontha) denticornis* (Panzer, 1806) males in Natural Park of "Tinença de Benifassà".

Cerodontha (Dizigomyza) crassiseta (Strobl, 1900)

= *Cerodontha (Dizigomyza) poae* Hendel 1931

Material examined: Tinença de Benifassà: 1♂, 2-12.x.2006; Font Roja: 1♂, 2-9.x.2006.

Key diagnostic characters: STROBL, 1900: 63. Scutellum with four bristles; third antennal segment round or axe-shaped, sometimes greatly enlarged in the male; frons black or brown; lunule grey; ocellar triangle not extended; arista conspicuously thickened throughout its length.

Distribution: Palaearctic: Belgium, Britain I., Czech Republic, French mainland, Germany, Hungary, Italian mainland, Poland, Spanish mainland.

Host-plants: *Dactylis.*

It is present in the Poeae tribe and widespread in Europe. The main identification characters are the short and thickened arista, and the male genitalia with an unusually short aedeagus.

Phenology: It has been captured puntually in autumn in both, "Tinença de Benifassà" and "Font Roja". Average temperatures of captures in "Tinença de Benifassà" were of 18ºC (23ºC max. and 13ºC min.) and in "Font Roja" 17,6ºC (24,4ºC max. and 10,9ºC min.).

Cerodontha (Poemyza) lateralis (Macquart, 1835)

= *Agromyza laminata* Brischke, 1880
= *Agromyza variceps* Zetterstedt, 1860
= *Agromyza vittigera* Zetterstedt, 1848

Material examined: Tinença de Benifassà: 1♂, 10-17.vii.2006.

Diagnostic characters: Orbits conspicuously widening towards base of antennae; 2 reclinate *ors*, 2 or 3 incurved *ori*; third antennal segment distinctly angulate at upper corner; 3+0 *dc*, *acr* in 4-5 rows; wing length 2-2.5 mm, last section of M_{3+4} 1 ½ times length of penultimate; anal projection knob-like; colour: frons blackish below, normally bright yellow adjoining ocellar triangle; orbits shining black in area of *ori*, bright yellow above; lunule yellowish, jowls brown, face and third antennal segment black, first and second segments yellowish; notopleura and upper margin of mesopleura bright yellow; mesonotum greyish-black, weakly shining; legs black, with all knees bright yellow, squamae and fringe, also wing base bright yellow; abdomen with all tergites narrowly yellow-bordered, front tergites yellow laterally.- Male genitalia as in SPENCER, 1976a: 195.

Distribution: Palaearctic: Belgium. Britain I., Czech Republic, Danish mainland, European Turkey, Finland, French mainland, Germany, Hungary, Italian mainland, Lithuania, Poland, Slovakia, Spanish mainland, Sweden, The Netherlands, Yugoslavia; East Palaearctic; Near East; Nearctic region.

Host-plants: *Agropyron, Dactylis, Hordeum, Secale, Triticum.*

Their hosts are present in the Triticeae tribe. It is widespread in Europe and also present in Japan. It closely resemble *Cerodontha (Poemyza) superciliosa* (Zetterstedt 1860), also in genitalia but distinguishable by the conical anal projection.

Phenology: It has been captured punctually in July in "Tinença de Benifassà" with average temperatures of 24.5ºC (31ºC max. and 18ºC min.).

Cerodontha (Poemyza) muscina (Meigen, 1830)

Material examined: Tinença de Benifassà: 1♂, 29.v.2006-5.vi.2006.

Diagnostic characters: Head with orbits conspicuously differentiated but not significantly proyecting above eye in profile; 2 *ors* and 2 (rarely 3) *ori*; jowls slightly less than 1/3 height of eye; third antennal segment small, round; 3+1 *dc*, *acr* irregularly in 4-5 rows; wing length 1.9-2.1 mm, last section of M_{3+4} normally 1 2/3 length of penultimate; colour: frons mat black, narrowly yellow around ocellar triangle; orbits bright yellow, variably brownish in area of *ori*, very narrowly dark along eye margin; lunule brown; jowls variable, from yellow to brown; face and all antennal segments black; mesonotum deep black, almost fully shining; pleura black, only mesopleura with narrow yellow upper margin; legs: femora black at least in lower half, normally two-thirds, contrasting yellow distally; tibiae and tarsi yellowish-brown; abdomen black; squamae yellow, margin and fringe dark.- Male genitalia: aedeagus with distal tubules relatively short, rotated to right, with distinct dilation at apex. See figure in SPENCER, 1976a: 193.

Distribution: Palaearctic: Austria, Belarus, Britain I., Czech Republic, Danish mainland, Estonia, Finland, French mainland, Germany, Hungary, Latvia, Lithuania, Norwegian mainland, Poland, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; Nearctic region.

Host-plants: *Agropyron, Bromus, Dactylis, Echinochloa, Ehrharta, Festuca, Hierochloe, Holcus, Hordeum, Lolium, Milium, Poa.*

It is recorded on 12 genera in seven tribes. It is common in Europe and North America. The male genitalia present the disthipallus partially rotated to the right.

Phenology: It has been captured punctually at the beginning of the summer in "Tinença de Benifassà" with average temperatures of 18ºC (26ºC max. and 10ºC min.).

5.3.2.5 Genus ***Chromatomyia*** Hardy, 1849

In the Palaearctic genus *Chromatomyia* is composed of 60 species. MARTINEZ (2004) cites the presence of 53 species in the European region. The total Spanish *Chromatomyia* composition is 16 species (CERNY & VALA, 2006).

This genus is closely related to and very similar with *Phytomyza* and *Napomyza*. Those three genera share many characteristics, particularly the frontorbital hairs being proclinate. The monophyly of *Chromatomyia* founded mainly by pupal and adult characters is resumed by DEMPEWOLF (2004): the "slipper-shaped" puparium remains within the mine with the ventral surface to the upper epidermis of the leaf (GRIFFITHS, 1967a). Frequently, the anterior spiracles project through the leaf epidermis. The apical section of the ejaculatory duct appears simple (not bifid), as in most *Phytomyza*. It lies below a lobe on the dorsal side of the aedeagus (GRIFFITHS, 1974).

Key diagnostic characters: Orbits normal, separated throughout by the frons; orbital setulae distinctly proclinate; costa only extending to R_{4+5}. The study of male genitalia is essential to discriminate this genus of others.

Known botanical families affected by *Chromatomyia* are resumed by BENAVENT-CORAI *et al.* (2005): Acanthaceae, Actinidiaceae, Alliaceae, Amaranthaceae, Anacardiaceae, Aspleniaceae, Balsaminaceae, Boraginaceae, Campanulaceae, Cannabaceae, Capparidaceae, Caprifoliaceae, Caryophyllaceae, Chenopodiaceae, Compositae, Convolvulaceae, Cruciferae, Cucurbitaceae, Cyperaceae, Dennstaedtiaceae, Dipsacaceae, Dryopteridaceae, Elaeagnaceae, Euphorbiaceae, Gentianaceae, Gramineae, Hydrophyllaceae, Juncaceae, Labiatae, Leguminosae, Loasaceae, Malvaceae, Onagraceae, Papaveraceae, Plantaginaceae, Plumbaginaceae, Polemoniaceae, Polygonaceae, Polypodiaceae, Primulaceae, Ranunculaceae, Resedaceae, Rutaceae, Saxifragaceae, Scrophulariaceae, Solanaceae, Tropaeolaceae, Umbelliferae, Urticaceae, Valerianaceae, Verbenaceae, Violaceae.

This genus includes polyphagous species with high economical impact as *Chromatomyia horticola* (Goureau, 1851) and *Chromatomyia syngenesiae* Hardy, 1849.

Chromatomyia horticola **(Goureau, 1851)**

= *Phytomyza bidensivora* Séguy, 1951
= *Phytomyza cucumidis* Macquart, 1854
= *Phytomyza fediae* Kaltenbach, 1860
= *Napomyza lactucae* Vimmer, 1928

= *Phytomyza linariae* Kaltenbach, 1862
= *Phytomyza meliloti* Brischke, 1882
= *Phytomyza nainiensis* Garg, 1971
= *Phytomyza pisi* Kaltenbach, 1864
= *Phytomyza subaffinis* Malloch, 1914
= *Phytomyza tropaeoli* Dufour, 1857
= *atricornis* auct. Not *Agromyza atricornis* Meigen, 1830, a nomen dubium.

Material examined: Tinença de Benifassà: 1♂, 20-27.v.2004; 3♂, 6-17.iv.2006; 4♂, 24.iv.2004-1.v.2004; 1♂, 1-8.v.2006; 1♂, 15-22.v.2006; 1♂, 18-25.xii.2006; 1♂, 12-20.iii.2007; 1♂, 20.iii.2007-2.iv.2007; 3♂, 2-9.iv.2007; 2♂, 9-16.iv.2007; Font Roja: 1♂, 27.ix.2004-4.x.2004.

Diagnostic characters: Mesonotum distinctively mat, ash-grey, without acrostichals. Head.- Frons broad, twice width of eye, not projecting above eye in profile; 2 equal *ors*, 1 incurved *ori*, orbital setulae in single row, proclinate; eye round, jowls deep up to 1/3 height of eye; third antennal segment small, round, arista appearing bare; mesonotum with 3+1 strong *dc*, 2nd, 3rd and 4th approximately equal, acrostichals lacking (at most one or two isolated hairs present); wing length from 2.2-2.6 mm, second costal section short, 1 2/3-2 times length of fourth; frons colour yellow or slightly darker, more orange, orbits always somewhat paler; third antennal segment and palps black; face greyish-black; mesonotum ash-grey, sides of thorax similar; legs with coxae black, femora black with all knees yellow, tibiae and tarsi black; veins pale, squamae grey, margin and fringe black. Male genitalia.- Aedeagus diverging arms above strongly developed, V-shaped, as in SPENCER, 1976b: 431.

Distribution: Palaearctic: Albania (Doubtful), Austria, Azores, Belgium, Britain I., Canary Is., Corsica, Czech Republic, Danish mainland, European Turkey, Faroe Is. (Doubtful), Finland, French mainland, Germany, Greek mainland, Hungary, Ireland, Italian mainland, Lithuania, Madeira, Malta, Republic of Moldova, Norwegian mainland, Poland, Portuguese mainland, Romania, Sardinia, Sicily, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; Afro-tropical region; East Palaearctic; Near East; Nearctic region; North Africa; Oriental region.

Host-plants: *Adonis, Aethusa, Ageratum, Ajuga, Alliaria, Allium, Althaea, Alyssum, Amaranthus, Anchusa, Andryala, Anethum, Anoda, Anthemis, Anthyllis, Antirrhinum, Apium, Arabidopsis, Arabis, Armoracia, Artemisia, Asperugo, Astragalus, Atriplex, Ballota, Bertorea, Beta, Bidens, Biscutella, Borago, Brassica, Coincya, Bunias, Bystropogon, Caccinia, Cakile, Calepina, Campanula, Cannabis, Capsella, Capsicum, Cardamine, Carduncellus, Carduus, Carthamus, Carum, Centaurea, Cephalaria, Cerastium, Cerinthe, Chaenorhinum, Chenopodium, Chrysanthemum, Cicer, Cineraria, Cirsium, Cissampelopsis, Cleome, Cochlearia, Collinsia, Conium, Convolvulus, Coreopsis, Coriandrum, Coringia, Coronopus, Cosmos, Cotinus, Cotula, Crambe, Crepis, Cucumis, Cucurbita, Cynara, Cynoglossum, Dahlia, Daucus, Descurainia, Diplotaxis, Dipsacus, Doronicum, Echium, Elsholtzia, Emilia, Erigeron, Erucastrum, Eryngium, Erysimum, Eschscholzia, Euphorbia, Gaillardia, Galeopsis, Galinsoga, Gazania, Gerbera, Glaucium, Glycine, Gnaphalium, Gynura, Gypsophila, Helianthus, Helichrysum, Heliotropium, Hesperis, Hibiscus, Hirschfeldia, Holcus, Humulus, Hyoscyamus, Hypochaeris, Iberis, Impatiens, Inula, Isatis, Jasione, Kitaibela, Knautia, Lactuca, Lagenaria, Lallemantia, Lamium, Lappula, Lathyrus, Launaea, Lavandula,* *Lavatera, Lens, Leonurus, Lepidium, Leucanthemum, Levisticum, Ligusticum, Limonium, Linaria, Linum, Lithospermum, Loasa, Lotus, Lupinus, Lycium, Lycopersicon, Lycopus, Malva, Matricaria, Matthiola, Maurandya, Medicago, Melampyrum, Melilotus, Melissa, Mentha, Mimulus, Moluccella, Moricandia, Myagrum, Myosotis, Nepeta, Nicotiana, Nonea, Oenothera, Omphalodes, Origanum, Oxytropis, Palaua, Papaver, Pastinaca, Peltaria, Petroselinum, Petunia, Peucedanum, Phacelia, Phaseolus, Phlox, Physalis, Phyteuma, Picris, Pisum, Plantago, Podonosma, Polygonum, Prunella, Pulmonaria, Raphanus, Reseda, Retama, Rhinanthus, Rhus, Rorippa, Rudbeckia, Ruta, Salicornia, Salvia, Satureja, Scorpiurus, Scorzonera, Scrophularia, Scutellaria, Senecio, Seseli, Silene, Sinapis, Sisymbrium, Solanum, Sonchus, Spinacia, Stachys, Stellaria, Symphytum, Tanacetum, Taraxacum, Teucrium, Thlaspi, Thunbergia, Tordylium, Torilis, Tragopogon, Trichodesma, Trifolium, Trigonella, Tropaeolum, Urtica, Valeriana, Valerianella, Verbascum, Verbena, Veronica, Vicia, Vigna, Viola, Withania.*

The genitalia of *Chromatomyia horticola* is essentially similar to *Chromatomyia syngenesiae* Hardy, 1849 but the supporting sclerites are significantly expanded apically. This species appears to have dispersed naturally across temperate areas of Africa to South America, it is common in parts of India and has reached Eastern Asia, but is entirely absent in Australia, New Zealand and the U.S.A.

Phenology: It has been captured in “Tinença de Benifassà” in spring and autumn, and in “Font Roja” only in autumn. It shows a high seasonality primarily determined by temperature and precipitation that determine the presence of host-plants. The averages temperatures at which captures occurred were between 14-16ºC with maximum temperatures exceeding 20ºC, and the minimum not less than 4ºC (Fig. 5-72). In “Font Roja” the only capture was produced with an average temperature of 21.1ºC (25.3ºC max. and 19.3ºC min.).

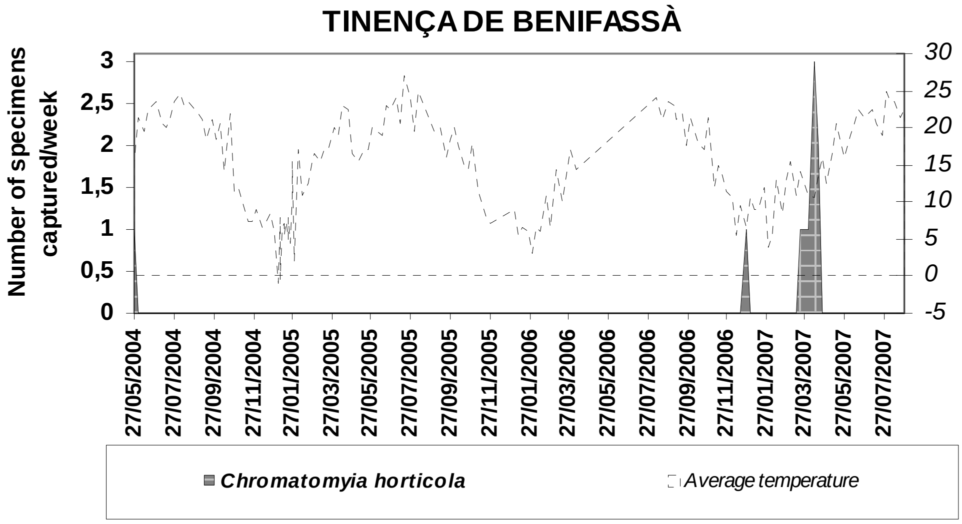


Figure 5-72. Space-time captures evolution of *Chromatomyia horticola* (Goureau, 1851) males in Natural Park of “Tinença de Benifassà”.

Chromatomyia succisae (Hering, 1922)

Material examined: <u>Tinença de Benifassà</u>: 2♂, 29.vii.2004-5.viii.2004; 1♂, 15-22.v.2006; 5♂, 22-29.v.2006; 1♂, 29.v.2006-5.vi.2006; 4♂, 5-12.vi.2006; 2♂, 19-26.vi.2006 ; <u>Font Roja</u>: 1♂, 27.ix.2004-4.x.2004.

Diagnostic characters: Frons twice width of eye, not projecting above eye in profile ; 2 equals *ors* ; eye round, sparsely haired ; jowls deep, up to ½ height of eye, cheeks broadly projecting below eye ; third antennal segment small, round; 3+1 strong *dc*, *acr* entirely lacking; wing length from 1.75 mm in male to 2.4 mm in female, second costal section short, from slightly more than 1 ½ to 2 times length of fourth; colour: frons brown above, more black towards lunule, orbits greyish-black; jowls brown, cheeks, face and antennae black; mesonotum mat ash-grey, sides of thorax and legs black; squamae grey, margin and fringe black.- Male genitalia: aedeagus as in SPENCER, 1976b: 509.

Distribution: Palaearctic: Britain I., Danish mainland, French mainland, Germany, Ireland, Italian mainland, Lithuania, Poland, The Netherlands.

Host-plants: *Dipsacus, Knautia, Scabiosa, Succisa.*

The larva of *Chromatomyia succisae* forms a narrow linear mine which can be largely obscured by strong purple discoloration of the leaf around the mined area. Genitalia morphology of *Chromatomyia scabiosarum* (de Meijere, 1934) and *Chr. succisae* reveals that these species represent an isolated group within *Chromatomyia*.

Phenology: Captures in "Tinença de Benifassà" were carried out in spring and summer. Maximum captures were of 5 males/week with averages temperatures of 24,5ºC (29ºC max. and 20ºC min.). In "Font Roja" the only capture was produced in autumn with an average temperature of 21.1ºC (25.3ºC max. and 16.9ºC min.).

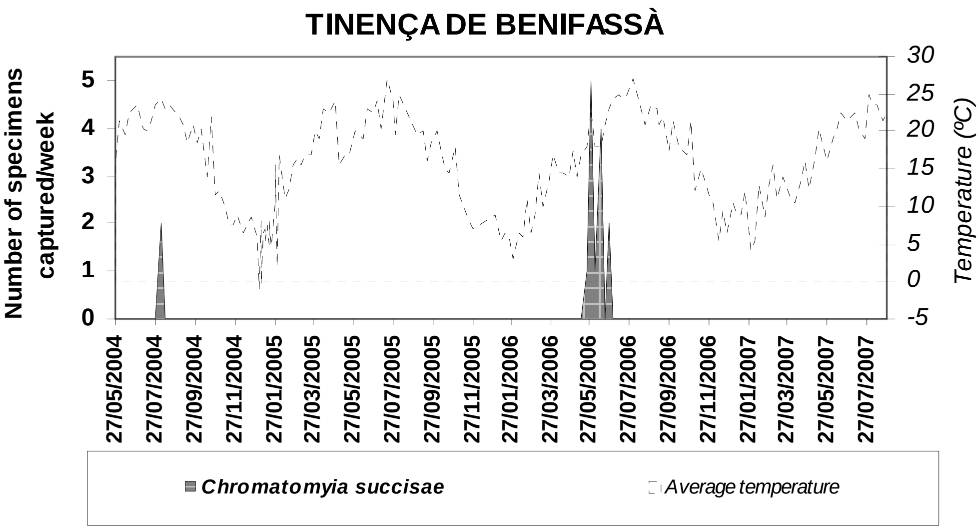


Figure 5-73. Space-time captures evolution of *Chromatomyia succisae* (Hering, 1922) males in Natural Park of "Tinença de Benifassà".

5.3.2.6 Genus ***Liriomyza*** Mik, 1894

Liriomyza genus comprises 147 species in the Palaearctic region, among which include the highest number of pest or harmful species to crops. BENAVENT-CORAI *et al.* (2004) cites as agronomic species within *Liriomyza* genus to *Liriomyza brassicae* (Riley, 1884), *Liriomyza bryoniae* (Kaltenbach, 1858), *Liriomyza cepae* (Hering, 1927), *Liriomyza cicerina* (Rondani, 1875), *Liriomyza congesta* (Becker, 1903), *Liriomyza dianthicola* (Venturi, 1949), *Liriomyza flaveola* (Fallén, 1823), *Liriomyza huidobrensis* (Blanchard, 1926), *Liriomyza orbona* (Meigen, 1830), *Liriomyza pusilla* (Meigen, 1830), *Liriomyza strigata* (Meigen, 1830), *Liriomyza trifolii* (Burgess in Comstock, 1880) and *Liriomyza xanthocera* (Czerny in Cerny & Strobl, 1909).

MARTINEZ (2004) cites the presence of 122 *Liriomyza* species in Europe. Later, several authors have cited the new presence in Spain of *Liriomyza aculeolata* Zlobin, 2002, *Liriomyza europaea* Zlobin, 2002, *Liriomyza pedestris* Hendel, 1931 (ZLOBIN, 2002) and *Liriomyza polygalae* Hering, 1927 (CERNY & MERZ, 2006). In the present thesis is cited the presence of 4 new records: *Liriomyza amoena* (Meigen, 1830), *Liriomyza erucifolii* de Meijere, 1944, *Liriomyza graminivora* Hering, 1949 and *Liriomyza samogitica* Pakalniškis, 1996. So that, the number of known *Liriomyza* species in continental Spain reach the figure of 44 species.

Key diagnostic characters: Orbits normal, separated throughout by the frons; orbital setulae erect, reclinate or absent; wing costa extending to apex of vein M_{1+2}; scutellum yellow, vein M_{1+2} nearest wing tip; orbits largely in plane of frons, frons yellow; stridulating mechanism in male present; pre-scutellar area normally dark, concolorous with mesonotum, only rarely yellow; epandrium at most with hairs, never with black, comb-like process (SPENCER, 1976a). These are the main diagnostic characters but other possibilities are also correct in *Liriomyza* genus, for example it exists species with the scutellum dark or lacking stridulating mechanism.

Study of male genitalia has revealed the presence of several well-defined natural groups within the genus. The *equiseti group* with the distiphallus consisting of long, paired tubules mining mainly on Equisetaceae, Campanulaceae and Umbelliferae; the *flaveola group* composed of grass feeders; the *puella group* miners on Compositae; and other groups that can be established (SPENCER, 1976a).

Botanical families attacked by *Liriomyza* are resumed by BENAVENT-CORAI *et al.* (2005a): Acanthaceae, Aizoaceae, Alismataceae, Alliaceae, Alstroemeriaceae, Amaranthaceae, Anacardiaceae, Apocynaceae, Aristolochiaceae, Asclepiadaceae, Asphodelaceae, Aspleniaceae, Avicenniaceae, Basellaceae, Bignoniaceae, Boraginaceae, Campanulaceae, Cannabaceae, Capparidaceae, Caprifoliaceae, Caryophyllaceae, Celastraceae, Chenopodiaceae, Commelinaceae, Compositae, Convallariaceae, Convolvulaceae, Crassulaceae, Cruciferae, Curbitaceae, Cyatheaceae, Dennstaedtiaceae, Dioscoreaceae, Dipsacaceae, Dryopteridaceae, Equisetaceae, Euphorbiaceae, Geniostomaceae, Gentianaceae, Geraniaceae, Globulariaceae, Goodeniaceae, Gramineae, Hemerocallidaceae, Hydrangeaceae, Hydrophyllaceae, Iridaceae, Juncaceae, Labiatae, Leguminosae, Liliaceae, Linaceae, Loasaceae, Malvaceae, Melanthiaceae, Menispermaceae, Moringaceae, Myoporaceae, Nyctaginaceae, Oleaceae, Onagraceae, Oxalidaceae, Passifloraceae, Papaveraceae, Pedaliaceae, Phytolaccaceae, Piperaceae, Pittosporaceae, Plantaginaceae, Plumbaginaceae, Polemoniaceae, Polygalaceae, Polygonaceae, Portulacaceae, Primulaceae, Ranunculaceae, Resedaceae, Rosaceae, Santalaceae, Sapindaceae, Saxifragaceae, Scrophulariaceae, Smilacaceae, Solanaceae, Strychnaceae, Thymelaeaceae, Tropaeolaceae, Turneraceae, Typhaceae, Umbelliferae, Urticaceae, Valerianaceae, Verbenaceae, Violaceae, Zygophyllaceae.

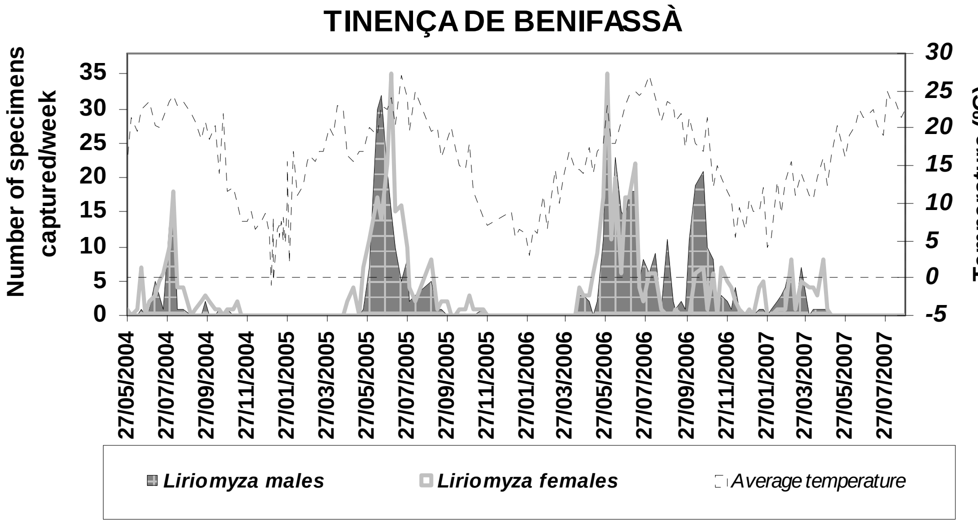


Figure 5-74. Space-time evolution of male and female captures of *Agromyza* genus in "Tinença de Benifassà" Natural Park.

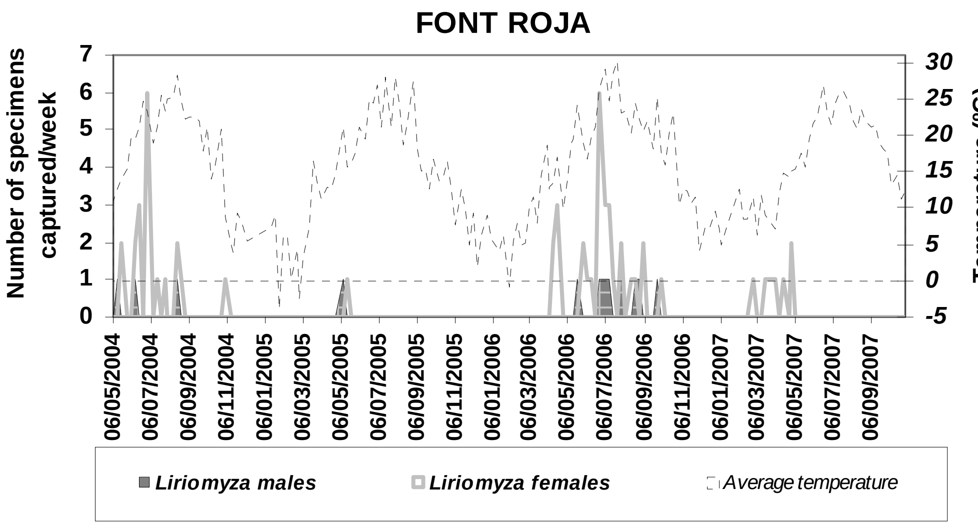


Figure 5-75. Space-time evolution of male and female captures of *Agromyza* genus in "Font Roja" Natural Park

Phenologycal evolution of genus *Liriomyza* in the three Natural Parks studied are really dependent on climate. "Tinença de Benifassà" presents continuing generations from mid-May until late September. The largest captures of males and females are achieved from late May to early July with 30-35 specimens/week for each sex, with average temperatures ranging from 20.5-23°C. The sex-ratio is usually close to 1, although in reproductive periods male can double female populations or vice versa. In autumn *Liriomyza* populations fluctuate greatly depending on climatic conditions. It presents marked generations in spring and autumn, subsequently 2-6 peaks appear dependent on weather conditions and the presence of host-plants (Fig. 5-74). “Font Roja” populations is composed basically of females, emerging males of a way little pronounced in the reproductive period of spring-summer. The number of generations is not well-defined 5-6 accused peaks of females appearing throughout the season. Maximum captures were of 6 female/week and 1 male/week with an average temperatures of 19.4-24.2ºC (Fig. 5-75). In “Lagunas de La Mata-Torrevieja” generations are displaced to the autumn and winter months in which average temperatures are in the range of 9-22ºC, with maximum captures of 21 males and 13 females/week. High temperatures since mid-May impede the presence of fresh flora which prevent the development of almost all Agromyzidae populations (Fig. 5-76).

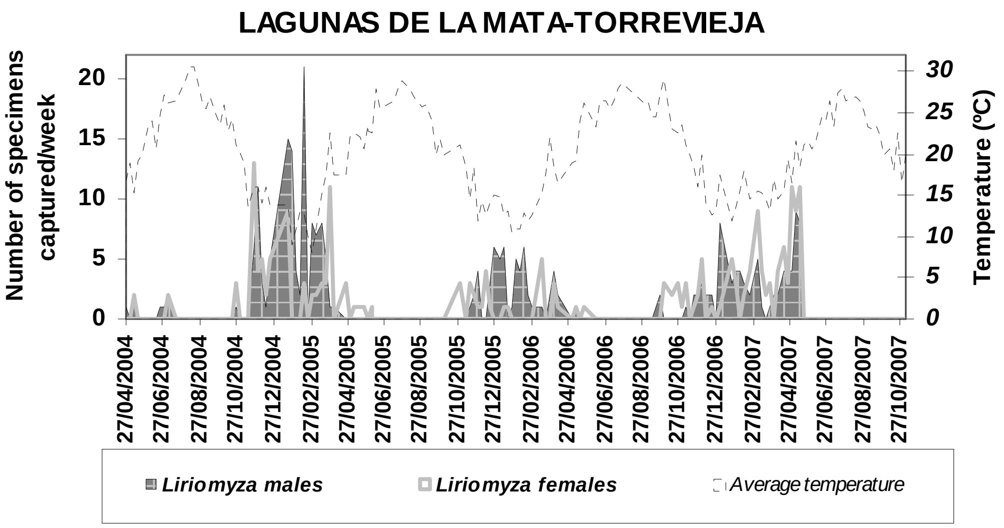


Figure 5-76. Space-time evolution of male and female captures of *Agromyza* genus in Natural Park of “Lagunas de La Mata-Torrevieja”.

Liriomyza brassicae (Riley, 1884)

= *Liriomyza bulnesiae* Spencer, 1963
= *Liriomyza cruciferarum* Hering, 1927
= *Liriomyza hawaiiensis* Frick, 1952
= *Phytomyza mitis* Curran, 1931
= *Liriomyza ornephila* Garg, 1971

Material examined: <u>Tinença de Benifassà</u>: 1♂, 25.vi.2004-1.vii.2004; 3♂, 1-8.vii.2004; 3♂, 8-15.vii.2004; 1♂, 15-22.vii.2004; 12♂, 22-29.vii.2004; 15♂, 29.vii.2004-5.viii.2004; 1♂, 5-12.viii.2004; 1♂, 12-19.viii.2004; 1♂, 16-23.v.2005; 2♂, 23-30.v.2005; 18♂, 6-13.vi.2005; 29♂, 13-20.vi.2005; 7♂, 20-27.vi.2005; 7♂, 27.vi.2005-4.vii.2005; 8♂, 4-11.vii.2005; 3♂, 11-18.vii.2005; 7♂, 18-28.vii.2005; 2♂, 28.vii.2005-1.viii.2005; 2♂, 1-8.viii.2005; 4♂, 8.viii.2005-2.ix.2005; 1♂, 2-12.ix.2005; 1♂, 8-15.v.2006; 6♂, 15-22.v.2006; 16♂,22-29.v.2006; 3♂, 29.v.2006-5.vi.2006; 10♂, 5-12.vi.2006; 5♂, 12-19.vi.2006; 8♂, 19-26.vi.2006; 12♂, 26.vi.2006-3.vii.2006; 15♂, 3-10.vii.2006; 2♂, 10-17.vii.2006; 7♂, 17-24.vii.2006; 4♂, 24.vii.2006-1.viii.2006; 5♂, 1-10.viii.2006; 1♂, 10-20.viii.2006; 6♂, 20-28.viii.2006; 2♂, 28-6.ix.2006; 1♂, 6-11.xi.2006; 1♂, 11-18.ix.2006; 1♂, 18-25.ix.2006; 8♂, 25.ix.2006-2.x.2008; 9♂, 2-

12.x.2006; 7♂, 12-23.x.2006; 6♂, 23-30.x.2006; 6♂, 30.x.2006-6.xi.2006; 2♂, 13-20.xi.2006; 2♂, 20-27.xi.2006; 1♂, 27.xi.2006-4.xii.2006; 2♂, 4-11.xii.2006; 1♂, 15-22.i.2007; 1♂, 19-26.ii.2007; 1♂, 12-20.iii.2007; 1♂, 23-30.iv.2007; Font Roja: 1♂, 19-26.vi.2006; 1♂, 26.vi.2006-3.vii.2006; 1♂, 25-31.vii.2006; Lagunas de La Mata-Torrevieja: 1♂, 22-29.xi.2005; 1♂, 4-11.iv.2006; 1♂, 2-9.v.2006; 1♂, 2-24.i.2007; 1♂, 24.iv.2007-1.v.2007; 1♂, 1-8.v.2007.

Diagnostic characters: Small species, with shining black mesonotum and orbits frequently darkened. Head with frons not projecting above eye, with 2 equal *ors* and 2 largely incurved *ori*; jowls deepest at rear, cheeks forming only narrow ring below eye; third antennal segment small, round; mesonotum with 3+1 *dc*, *acr* in 4 rows; wing length from 1.25 mm in male to 1.6 mm in female, discal cell small, last section of vein M_{3+4} 3 times length of penultimate; frons colour pale yellow, hind margin of eye black, with normally both vertical bristles on dark ground; orbits frequently darkened, black or at least brownish, sometimes only very narrowly so adjoining margin of eye, in paler specimens no trace of this darkening detectable; all antennal segments yellow; mesopleura normally with a dark area filling lower third and this may also extend up hind-margin, coxae and femora bright yellow, tibiae and tarsi darker, brownish; abdomen predominantly shining black, tergites with hind-margins at most narrowly yellow, laterally more broadly so; squamae yellow, margin and fringe dark. Male genitalia.- Aedeagus as in SPENCER, 1973: 154; ejaculatory apodeme with unusually large blade.

Distribution: Palaearctic: Canary Is., Corsica, European Turkey, French mainland, Germany, Romania, Spanish mainland; Afro-tropical region; Australian region; East Palaearctic; Near East; Nearctic region; Neotropical region; North Africa; Oriental region.

Host-plants: *Barbarea, Brassica, Cakile, Cleome, Hirschfeldia, Isatis, Lepidium, Matthiola, Moricandia, Pisum, Raphanus, Reseda, Sinapis, Sisymbrium, Tropaeolum.*

Liriomyza brassicae was discovered in the United States on *Brassica* (cabbage) and is now known on 15 further genera. It is semi-cosmopolitan but in Europe is really typical of Botanical Gardens. It is present throughout the Old World tropics, particularly on Capparaceae and *Tropaeolum* (Tropaeolaceae), a favourite host, it occurs commonly in Australia, including Tasmania. It occurs occasionally on Resedaceae and an unusual switch is represented by its occasional occurrence on *Pisum*, on which it has been found on several occasions in Kenya and India. The male genitalia suggests possible relationship with *Liriomyza baccharidis* Spencer, 1963 (Asteraceae). Although *L. brassicae* cannot be reliably distinguished from the important pest *Liriomyza sativae* Blanchard, 1938 on external characters, the genitalia are entirely distinct.

Phenology: It is present in all Natural Parks studied. In “Tinença de Benifassà” it is present all season preferably when temperatures are high from mid May to late September or early December in mild winters. It presents 1-5 generations in Spring and 1-3 in autumn depending on weather conditions. Maximum captures were 29 males/week with average temperatures of 23ºC (30ºC max. and 16ºC min.). In “Font Roja” average temperature preference is 25.9º, and in “Lagunas de La Mata-Torrevieja” the behaviour of *L. brassicae* seems to have a preference for medium temperatures established around 16.7ºC.

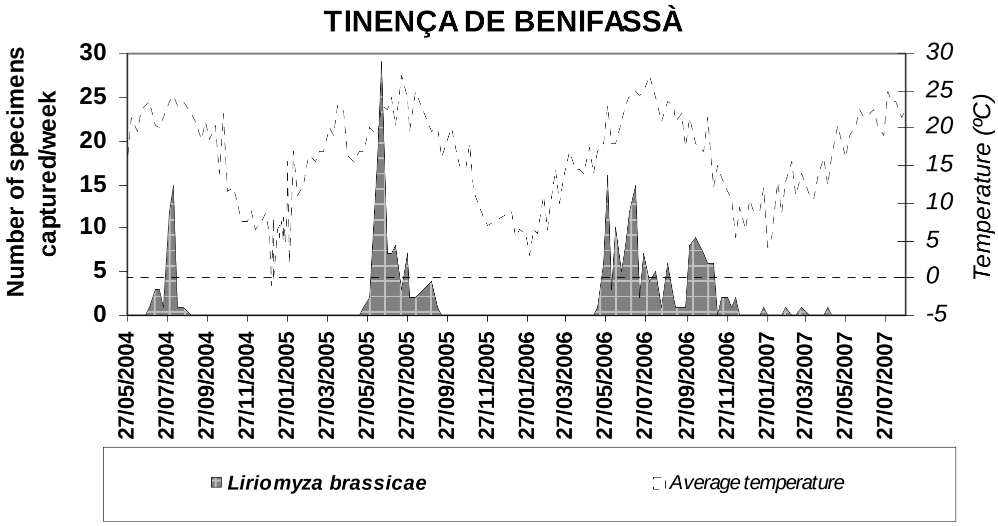


Figure 5-77. Space-time captures evolution of *Liriomyza brassicae* (Riley, 1884) males in Natural Park of "Tinença de Benifassà".

Liriomyza bryoniae (Kaltenbach, 1858)

= *Liriomyza citrulli* Rohdendorf, 1950
= *Liriomyza hydrocotylae* Hering, 1930
= *Liriomyza mercurialis* Hering, 1932
= *Liriomyza nipponallia* Sasakawa, 1961
= *Liriomyza solani* Hering, 1927
= *Liriomyza triton* Frey, 1945

Material examined: Tinença de Benifassà: 1♂, 10-17.vi.2004; 2♂, 1-8.vii.2004; 2♂, 29.vii.2004-5.viii.2004; 1♂, 16-23.ix.2004; 1♂, 21-28.x.2004; 9♂, 23-30.v.2005; 11♂, 6-13.vi.2005; 3♂, 13-20.vi.2005; 14♂, 20-27.vi.2005; 8♂, 27.vi.2005-4.vii.2005; 2♂, 4-11.vii.2005; 1♂, 11-18.vii.2005; 1♂, 18-28.vii.2005; 1♂, 8.viii.2005-2.ix.2005; 1♂, 12-19.ix.2005; 1♂, 17-24.iv.2006; 1♂, 24.iv.2006-1.v.2006; 3♂, 15-22.v.2006; 8♂, 22-29.v.2006; 5♂, 29.v.2006-5.vi.2006; 11♂, 5-12.vi.2006; 5♂, 12-19.vi.2006; 8♂, 19-26.vi.2006; 5♂, 26.vi.2006-3.vii.2006; 1♂, 10-17.vii.2006; 2♂, 17-24.vii.2006; 3♂, 1-10.viii.2006; Lagunas de La Mata-Torrevieja: 1♂, 4-11.v.2004; 1♂, 15-22.vi.2004; 1♂, 22-29.vi.2004.

Diagnostic characters: Head with 2 equal *ors* and 2 (rarely 3) *ori*, orbital setulae minute, sparse, reclinate or almost entirely lacking; third antennal segment small, round, with normal short pubescence; mesonotum with 3+1 strong *dc*, *acr* in 4 rows; wing length from 1.75 to 2.1 mm, discal cell relatively large, last section of vein M_{3+4} twice length of penultimate; colour: frons, orbits and antennae bright yellow, hind-margin of eye black beyond base of *vte* but both *vt* on yellow ground; mesonotum black, largely shining but with distinct mat undertone; mesopleura predominantly yellow, normally with small black bar on lower margin which can extend up front margin; legs: femora bright yellow but with variable brownish striations, tibiae and tarsi more brownish; squamae yellowish, margin dark, fringe ochrous to brown.- Male genitalia as in SPENCER, 1976a: 233.

Distribution: Palaearctic: Albania, Austria, Azores, Belarus, Belgium, Britain I., Bulgaria, Canary Is., Channel Is., Corsica, Crete, Croatia, Cyclades Is., Czech Republic, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Greek mainland, Hungary, Italian mainland, Lithuania, Malta, Republic of Moldova, Norwegian mainland, Poland, Portuguese mainland, Romania, Sicily, Slovenia, Spanish mainland, Sweden, The Netherlands, Ukraine, Yugoslavia; East Palaearctic; Near East; North Africa; Oriental region.

Host-plants: *Aethionema, Alisma, Alliaria, Ajuga, Amaranthus, Anarrhinum, Anthyllis, Antirrhinum, Apium, Arabis, Astragalus, Atriplex, Atropa, Barbarea, Basella, Beta, Brugmansia, Bryonia, Caiophora, Callistephus, Capsella, Capsicum, Celosia, Centaurea, Centaurium, Centranthus, Chaenorhinum, Chenopodium, Chorispora, Cirsium, Citrullus, Cleome, Collinsia, Coriandrum, Coronilla, Cucumis, Cucurbita, Cymbalaria, Dahlia, Datura, Diptychocarpus, Erysimum, Galega, Galeopsis, Galinsoga, Gerbera, Gentiana, Gypsophila, Heliophila, Hesperis, Hibiscus, Hydrocotyle, Hyoscyamus, Kickxia, Lactuca, Lagenaria, Lallemantia, Lamium, Lathyrus, Lavatera, Lens, Leonurus, Levisticum, Linaria, Lisianthus, Lupinus, Lycium, Lycopersicon, Malva, Maurandya, Medicago, Melilotus, Mercurialis, Nicandra, Nicotiana, Ononis, Oxalis, Oxytropis, Peltaria, Petroselinum, Petunia, Phacelia, Phaseolus, Phlox, Physalis, Piper, Pisum, Polemonium, Primula, Proboscidea, Raphanus, Ricinus, Salpiglossis, Saponaria, Scopolia, Scrophularia, Sedum, Sinapis, Sisymbrium, Solanum, Sonchus, Spergularia, Spinacia, Stellaria, Thermopsis, Trifolium, Trigonella, Tropaeolum, Verbascum, Verbena, Vicia, Withania.*

Liriomyza bryoniae is a highly polyphagous species and occurs commonly as a significant pest on several genera of cultivated cucurbits in Europe but is rarely found on its original host, *Bryonia*. The larval posterior spiracles have about ten spiracular pores on each process. The male genitalia is similar to *Liriomyza strigata* (Meigen, 1830), another polyphagous species which occurs most commonly on Asteraceae. However, the leaf mines of the two species are entirely different, with *L. bryoniae* forming an irregular linear mine on any part of the leaf, while the mine of *L. strigata* always follows the midrib, with short offshoots into the leaf blade.

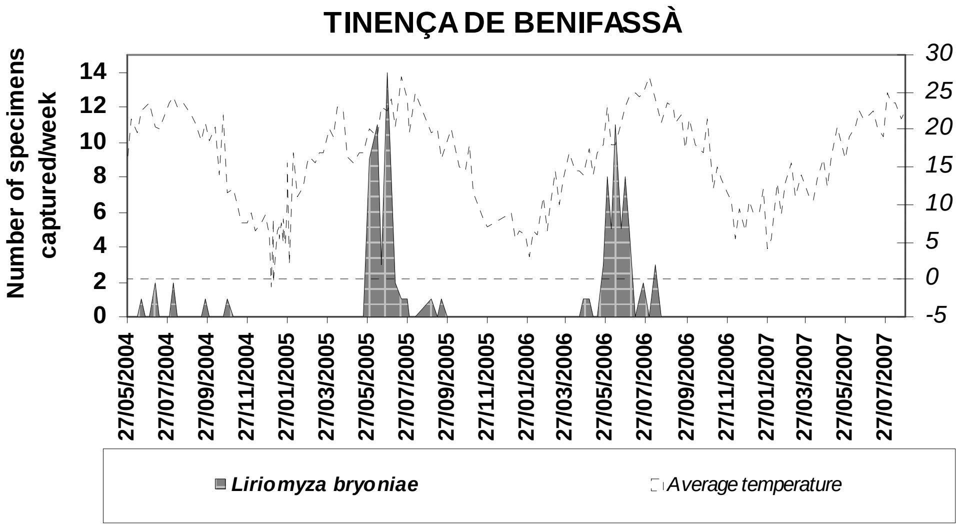


Figure 5-78. Space-time captures evolution of *Liriomyza bryoniae* (Kaltenbach, 1858) males in Natural Park of “Tinença de Benifassà”.

Phenology: It is largely present in "Tinença de Benifassà" in summer. It presents 4-6 generations in spring with 2-3 very sharp peaks from late May to late June. Maximum captures were produced with average temperatures of 22.5ºC (29ºC max. and 16ºC min.). In "Lagunas de La Mata-Torrevieja" it is present at the end spring and the beginning of summer with average temperatures of 15.2-27.2ºC.

Liriomyza cicerina (Rondani, 1875)

= *Agromyza ciceri* Navarro, 1903
= *Liriomyza ononidis* de Meijere, 1925
= *Liriomyza trichophthalma* Hendel, 1931

Material examined: Lagunas de La Mata-Torrevieja: 1♂, 17-24.iv.2007; 2♂, 1-8.v.2007; 5♂, 8-16.v.2007.

Diagnostic characters: Frons 1 ½ times width of eye, increasingly projecting above eye towards base of antennae, orbits conspicuously differentiated, raised and paler than frons; 1 reclinate *ors*, 2 or sometimes 3 incurved *ori*, orbital setulae sparse, reclinate; jowls deeply extended at rear, there 1/3 vertical height of eye, cheeks forming broad ring below eye; third antennal segment small, round; mesonotum: 3+1 *dc*, acrostichals sparse, irregularly in 2 to 4 rows; wing: length from 1.3 to 1.5 mm, costa extending strongly to vein M_{1+2}, discal cell small, last section of M_{3+4} times length of penultimate; colour: frons orange-yellow, orbits distinctly paler yellow, sometimes narrowly darkened beside eye margin and blackish around base of *ors*; vertex dark, at least outer vertical bristle on black ground; jowls orange, face somewhat greyish, palps black; third antennal segment variably darkened, in darkest specimens almost entirely black, first and second segments yellowish; mesonotum deep black, shining from behind but more mat viewed from front; mesopleura normally black along lower and front margins, paler above, more rarely with only a small black patch on lower margin; legs dark, femora although basically yellow largely darkened by variable black striations.- Male genitalia: aedeagus as in SPENCER, 1976a: 240.

Distribution: Palaearctic: Albania (doubtful), Austria, Britain I., Czech Republic, Danish mainland, European Turkey, French mainland, Germany, Greek mainland, Italian mainland, Lithuania, Poland, Portuguese mainland, Romania, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Ukraine, Yugoslavia; Near East; North Africa.

Host-plants: *Cicer, Hymenocarpos, Melilotus, Ononis.*

Liriomyza cicerina mainly feeds on *Cicer arietinum* L. (chick pea) in the Meditarranean area, on which it can be a serious pest. The genitalia show that it is related to species on Asteraceae, for example *Liriomyza sonchi* Hendel, 1931.

Phenology: It is present in spring in "Lagunas de La Mata-Torrevieja", probably by the presence of greenhouses near the Natural Park. They were captured from mid-April to mid May with average temperatures of 18.5-21.5ºC (26ºC max. and 13ºC min.).

Liriomyza congesta (Becker, 1903)

= *Liriomyza centaureana* Hering, 1936

= *Liriomyza leguminosarum* de Meijere, 1924
= *Liriomyza minima* Hendel, 1931
= *Liriomyza nigripleura* Rydén, 1956
= *Liriomyza parva* Hendel, 1931
= *Liriomyza taraia* Garg, 1971
= *Liriomyza trifolii* auct.

Material examined: Tinença de Benifassà: 1♂, 16-23.ix.2004; 1♂, 1-8.viii.2005; 1♂, 22-29.v.2006; 1♂, 29.v.2006-5.vi.2006; 2♂, 12-19.vi.2006; 1♂, 19-26.vi.2006; 1♂, 3-10.vii.2006; 1♂, 10-17.vii.2006; 1♂, 1-10.viii.2006; 1♂, 20-28.viii.2006; Font Roja: 1♂, 3-10.vii.2006; Lagunas de La Mata-Torrevieja: 1♂, 29.vi.2004-6.vii.2004; 1♂, 1-8.v.2007; 1♂, 8-16.v.2007.

Diagnostic characters: Orbits normally with 4 bristles, the 2 *ors* equal and reclinate, the 2 *ori* partially incurved, the lower more so; in smaller specimens one bristle is frequently absent; orbital setulae sparse, reclinate; third antennal segment small, round, with only slight pubescence; mesonotum with 3+1 *dc* and *acr* in only 2 rows; wing length normally from 1.3 mm in male to 1.7 mm in female, venation somewhat variable, second costal section normally 3 times length of fourth but ranging from 2.5 to 4 times; discal cell small, last section of M_{3+4} from 3 to 4 times length of penultimate; frons, orbits and antennae yellow, both *vt* on yellow ground but hind-margin of eye black beyond base of *vte*; mesonotum mat blackish-grey, pleura largely yellow, mesopleura variably darkened, with either small black bar on lower margin or entire front and lower margins black; sternopleura and hypopleura partially black but divided by yellow; legs largely yellow but femora with variable brownish or blackish striations; abdomen largely black but tergites partially yellow laterally; in darkest melanic form seen from *N*. Sweden hind-margin of eye black to base of *vti*, mesopleura black also on hind-margin, femora largely black above but clearly yellow below, tibia and tarsi black. Male genitalia aedeagus as in SPENCER, 1976a: 243.

Distribution: Palaearctic: Albania, Austria, Belgium, Britain I., Canary Is., Corsica, Czech Republic, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Hungary, Ireland, Italian mainland, Latvia, Lithuania, Malta, Republic of Moldova, Norwegian mainland, Poland, Romania, Sardinia, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; East Palaearctic; Near East; North Africa; Oriental region.

Host-plants: *Anthyllis, Astragalus, Caragana, Cicer, Colutea, Coronilla, Euphorbia, Glycine, Glycirrhiza, Hippocrepis, Hymenocarpos, Lathyrus, Lens, Lotus, Lupinus, Medicago, Melilotus, Onobrychis, Ononis, Ornithopus, Oxytropis, Phaseolus, Pisum, Robinia, Scorpiurus, Trifolium, Trigonella, Vicia.*

In Europe *Liriomyza congesta* is common on *Lathyrus*, *Pisum* and *Vicia*, and has been recorded on *Lens*; it is also equally common on the Trifolieae. The male genitalia show that it is closely related to *Liriomyza fricki* Spencer, 1965, which was earlier confused with *Liriomyza trifolii* (Burgess in Comstock 1880). The genitalia clearly suggests that *L. fricki* is more closely related to *L. congesta* in Europe than to *L. trifolii* in North America.

Phenology: It is present is all three Natural Parks studied commonly when the temperatures are high. In general captures were low. In "Tinença de Benifassà" maximum captures were 2 males/week with average temperatures of 21ºC (27ºC max. and 15ºC min.). The number of generations is variable dependant on meteorological factors. In the spring of 2006 the presence of 5 peaks was observed, but with non significant captures. In "Font Roja" captures were produced with very high average temperatures of 29.2ºC (37.5ºC max. and 21ºC min). While in "Lagunas de La Mata-Torrevieja" captures were produced when average temperatures were of 18.5-26.2ºC (27.5ºC max. and 15ºC min.).

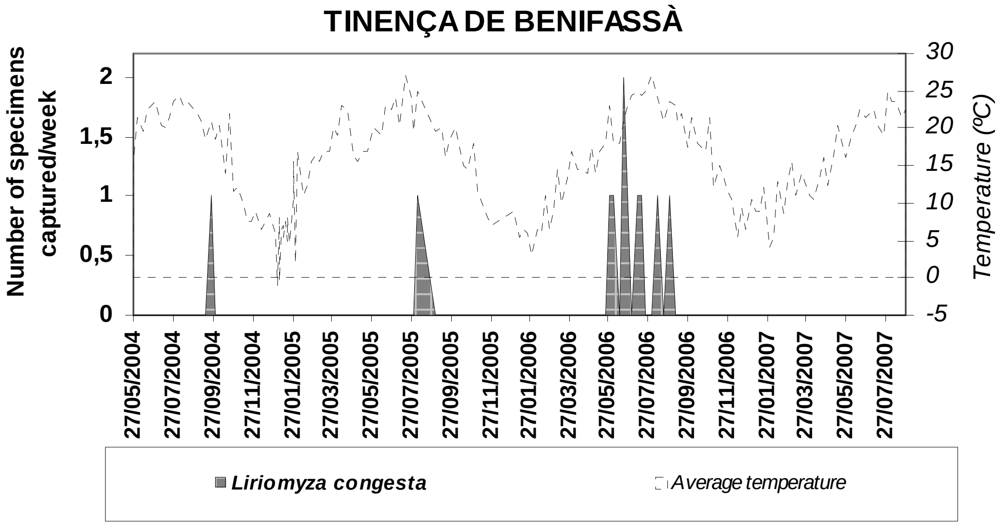


Figure 5-79. Space-time captures evolution of *Liriomyza congesta* (Becker, 1903) males in Natural Park of "Tinença de Benifassà".

Liriomyza eupatorii (Kaltenbach, 1873)

= *Liriomyza orbitella* Hendel 1931

Material examined: Tinença de Benifassà: 1♂, 6-13.vi.2005; 1♂, 11-18.vii.2005; 2♂, 29.v.2006-5.vi.2006; 1♂, 5-12.vi.2006.

Diagnostic characters: Frons, orbits and antennae yellow; hind-margin of eye black to base of *vti*; mesonotum deep black but slightly mat, *acr* in 4 rows; mesopleura with black bar along lower margin and half way up front margin; legs: femora bright yellow, at most faintly darkened by brownish striations, tibiae and tarsi darker, brownish-yellow; squamal fringe dark; wing length 2 mm.- Male genitalia: aedeagus as in SPENCER, 1976a: 247.

Distribution: Palaearctic: Belgium, Britain I., Corsica, Czech Republic, Danish mainland, Estonia, Finland, French mainland, Germany, Hungary, Ireland, Italian mainland, Lithuania, Norwegian mainland, Poland, Spanish mainland, Sweden, Switzerland, The Netherlands; Nearctic region.

Host-plants: *Aster, Eupatorium, Galeopsis, Lapsana, Solidago.*

In Europe *Liriomyza eupatorii* commonly feeds in Europe on *Eupatorium* and some other genera of Asteraceae but also regularly on *Galeopsis tetrahit* L. (Lamiaceae). The spiral beginning of the leaf mine is very distinctive. The male genitalia show that *L. eupatorii* is closely related to *Liriomyza pusilla* (Meigen, 1830) which is widespread in Europe and is now accepted as having an extensive distribution across Asia, with hosts exclusively in the Asteraceae. It can thus be accepted that this family provides the primary hosts of *L. eupatorii*. Its occurrence on *Galeopsis* is frequent and this is a regular alternate host. This species can be considered pre-polyphagous due to the great possibility of colonization of other hosts.

Phenology: It is present in summer in "Tinença de Benifassà" with average an temperature range of 19-27ºC (32ºC max. and 15ºC min.).

Liriomyza flaveola (Fallén, 1823)

= *Agromyza albicornis* Meigen, 1838
= *Agromyza blanda* Meigen, 1830
= *Agromyza variegata* Meigen, 1838

Material examined: Tinença de Benifassà: 1♂, 25.ix.2006-2.x.2006; Font Roja: 1♂, 6-13.v.2004.

Diagnostic characters: Head largely yellow, including all antennal segments and palps, hind-margin of eye dark at least to base of *vti*; mesonotum deep black though generally distinctly mat, with 3+1 strong *dc*, *acr* irregularly in 4 rows; pleura broadly yellow above, mesopleura with mesopleural bristle always on yellow ground; legs: femora black but broadly yellow distally, for distance greater than width of femora; wing length from 2.1-2.7 mm, last section of M_{3+4} approx. twice length of penultimate; abdomen with tergites broadly yellow laterally; squamae yellow, margin and fringe black.- Male genitalia: aedeagus as in SPENCER, 1976a: 247.

Distribution: Palaearctic: Belarus, Belgium, Britain I., Canary Is., Channel Is., Czech Republic, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Hungary, Ireland, Italian mainland, Lithuania, Monaco, Norwegian mainland, Poland, Spanish mainland, Sweden, Switzerland, The Netherlands; East Palaearctic; North Africa; Oriental region.

Host-plants: *Avena, Bromus, Dactylis, Holcus, Hordeum, Milium, Poa.*

Liriomyza flaveola is present on five genera in four tribes. It is one of the most common species on grasses. The male genitalia present a curvature of the distiphallus characteristic of the group. It is really closely linked to *Liriomyza graminivora* Hering, 1949, *Liriomyza orbona* (Meigen, 1830), *Liriomyza phryne* Hendel, 1931 and *Liriomyza richteri* Hering, 1927. All five species cited only occur on the tribu Pooideae.

Phenology: In "Tinença de Benifassà" captures were produced in autumn with average temperatures of 21.5ºC (29ºC max. and 14ºC min.), while in "Font Roja" captures were produced in spring with average temperatures of 12.6ºC (18.3ºC max. and 6.9ºC min.). Due to low captures it is difficult to obtain a clear conclusion of the phenology of this species.

Liriomyza orbona (Meigen, 1830)

= *Agromyza fuscolimbata* Strobl, 1900
= *Liriomyza orbonella* Hendel, 1931

Material examined: Tinença de Benifassà: 1♂, 6-17.iv.2006; 1♂, 24.iv.2006-1.v.2006; 1♂, 15-22.v.2006; 1♂, 29.v.2006-5.vi.2006; 1♂, 11-18.ix.2006; 1♂, 25.ix.2006-2.x.2006; 5♂, 2-12.x.2006; 3♂, 12-23.x.2006; 1♂, 30.x.2006-6.xi.2006; 1♂, 20-27.xi.2006; 1♂, 4-11.xii.2006; 1♂, 11-18.xii.2006; 1♂, 8-15.i.2007; 1♂, 5-12.ii.2007; 1♂, 12-19.ii.2007; 1♂, 19-26.ii.2007; 1♂, 12-20.iii.2007; 1♂, 9-16.iv.2007; 1♂, 16-23.iv.2007; Font Roja: 1♂, 2-9.v.2005; Lagunas de La Mata-Torrevieja: 6♂, 16-23.xi.2004; 11♂, 23-30.xi.2004; 3♂, 30.xi.2004-7.xii.2004; 1♂, 7-14.xii.2004; 4♂, 14-21.xii.2004; 14♂, 21.xii.2004-18.i.2005; 8♂, 18-26.i.2005; 1♂, 26.i.2005-2.ii.2005; 17♂, 8-15.ii.2005; 6♂, 22.ii.2005-1.iii.2005; 6♂, 1-8.iii.2005; 8♂, 8-15.iii.2005; 5♂, 15-22.iii.2005; 1♂, 22-29.iii.2005; 1♂, 29.iii.2005-5.iv.2005; 1♂, 8-15.xi.2005; 1♂, 15-22.xi.2005; 3♂, 22-29.xi.2005; 1♂, 13-20.xii.2005; 2♂, 20-27.xii.2005; 2♂, 27.xii.2005-3.i.2006; 1♂, 3-10.i.2006; 1♂, 21-28.ii.2006; 1♂, 28.ii.2006-14.iii.2006; 1♂, 21-28.iii.2006; 2♂, 28.iii.2006-4.iv.2006; 1♂, 4-11.iv.2006; 1♂, 14-21.xi.2006; 1♂, 21-28.xi.2006; 1♂, 28.xi.2006-5.xii.2006; 2♂, 5-12.xii.2006; 1♂, 26.xii.2007-2.i.2007; 2♂, 2-24.i.2007; 3♂, 24-30.i.2007; 4♂, 30.i.2007-6.ii.2007; 2♂, 6-13.ii.2007; 1♂, 13-20.ii.2007; 2♂, 20.ii.2007-6.iii.2007; 1♂, 20-27.iii.2007; 2♂, 3-10.iv.2007; 1♂, 1-8.v.2007.

Diagnostic characters: Closely resembling darker than *Liriomyza richteri* Hering, 1927, essential characters being the darkened third antennal segment, which is brownish or even black on outside or along upper margin; both *vt* on dark ground, orbits adjoining eye margin frequently narrowly black and area between upper *ors* and *vti* variably brownish; mesonotum mat black; mesopleura largely black, narrowly yellow above but bristle always on black; femora black, with all knees conspicuously yellow; wing length 1.7-2.6 mm, discal cell variable, last section of M_{3+4} from 2 to 3 times length of penultimate.- Male genitalia: aedeagus as in SPENCER, 1976a: 261.

Distribution: Palaearctic: Britain I., Canary Is., Channel Is., Crete, Czech Republic, Danish mainland, Dodecanese Is., European Turkey, Finland, French mainland, Germany, Hungary, Ireland, Italian mainland, Lithuania, Madeira, Malta, Poland, Sicily, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; Near East; North Africa.

Host-plants: *Avena, Deschampsia, Poa.*

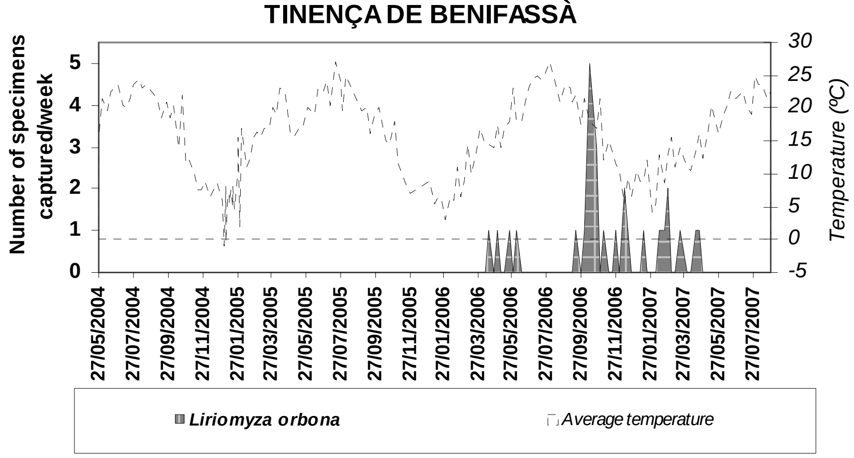


Figure 5-80. Space-time captures evolution of *Liriomyza orbona* (Meigen, 1830) males in Natural Park of "Tinença de Benifassà".

It is typical in spring mining over the tribes Aveneae and Poeae. The male genitalia indicates a close relationship with *Liriomyza phryne* Hendel, 1931.

Phenology: It is abundantly present in the Natural Parks of “Tinença de Benifassà” and “Font Roja”. In “Font Roja” captures were very punctual. They present a great seasonality between years. In “Tinença de Benifassà” captures were only carried out in 2006-2007 years with a lot of peaks indicating 6-8 generations annually. Prefered average temperatures were 18ºC (23ºC max. and 13ºC min.). In “Lagunas de La Mata-Torrevieja” captures occurred from autumn to spring when temperatures were less extreme. The highest captures of 17 males/week were produced with average temperatures of 12.8ºC (16ºC max. and 9.5ºC min.). The only capture obtained in “Font Roja” was with an average temperatures of 21.2ºC (27.5ºC max. 15ºC min.).

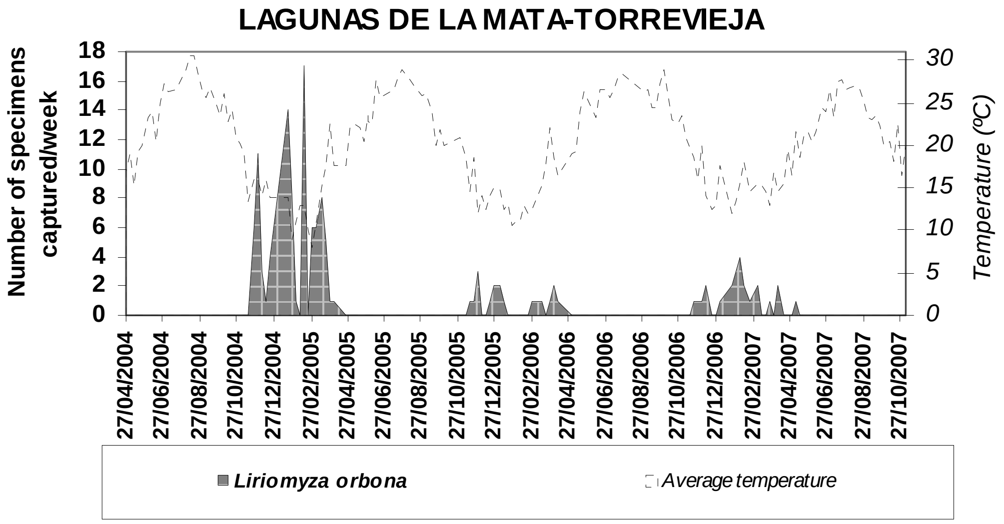


Figure 5-81. Space-time captures evolution of *Liriomyza orbona* (Meigen, 1830) males in Natural Park of “Lagunas de La Mata-Torrevieja”.

Liriomyza pusilla (Meigen, 1830)

= *Liriomyza bellidis* de Meijere, 1925 As subsp. of *Liriomyza fasciola* (Meigen).
= *Agromyza fasciola* Meigen, 1838

Material examined: Tinença de Benifassà: 1♂, 8-15.v.2006; 1♂, 5-12.vi.2006; 1♂, 26.vi.2006-3.vii.2006; 1♂, 3-10.vii.2006; 1♂, 20-28.viii.2006.

Diagnostic characters: Frons, orbits and antennae yellow; 2 equal reclinate *ors*, 2 largely incurved *ori*; hind-margin of eye black to base of *vti*, mesonotum brilliantly shining black, *acr* in 4 rows; mesopleura variably darkened in lower half; legs: coxae and femora yellow, the latter slightly darkened with variable brownish striations, tibiae and tarsi darker, brown; wing length 1.6-2 mm, last section of vein M_{3+4} little more than twice length of penultimate.- Male genitalia: aedeagus as in SPENCER, 1976a: 266.

Distribution: Palaearctic: Albania, Belgium, Britain I., Corsica, Czech Republic, Danish mainland, European Turkey, Finland, French mainland, Germany, Ireland, Italian mainland, Lithuania, Republic of Moldova, Poland, Romania, Sicily, Slovakia, Spanish mainland, Sweden, The Netherlands; Oriental region.

Host-Plants: *Aster, Bellis, Bidens, Callistephus, Crassocephalum, Epaltes, Solidago, Synedrella, Tithonia, Vernonia, Xanthium.*

Liriomyza pusilla mines were irregularly linear from the beginning. Its genitalia is close to *Liriomyza asterivora* Sasakawa, 1956. Both with *Liriomyza eupatorii* Kaltenbach, 1873 represent a monophyletic complex and, with its wide distribution in Europe, Asia, Japan and North America, it must be of early origin. The tendency for a spiral start of the leaf mine, sometimes detectable in *L. pusilla* in part of its range (India) and also in *L. asterivora* in Japan, but fully and consistently developed in *L. eupatorii* is presumably a relatively recent evolutionary modification.

Phenology: It has been captured in "Tinença de Benifassà" at the end of spring and summer with average temperatures of 17-25ºC (33ºC max. and 11ºC min.).

Liriomyza sonchi Hendel, 1931

Material examined: Lagunas de La Mata-Torrevieja: 1♂, 27.iv.2004-4.v.2004.

Diagnostic characters: 2 equal reclinate *ors*, 2 incurved *ori*; third antennal segment with short, normal pubescence; mesonotum with 3+1 strong *dc*, *acr* in 4 rows; wing length up to 1.9 mm, last section of M_{3+4} three times length of penultimate, second cross-vein at right angles to vein M_{3+4}; colour: frons, orbits and antennae entirely yellow; hind-margin of eye normally entirely yellow, more rarely black for short distance well beyond base of *vte*, both *vt* clearly on yellow ground; mesonotum black, only moderately shining; mesopleura with only small black bar on lower margin, black of sterno- and hypopleura broadly divided by yellow; legs: coxae and femora bright yellow, margin and fringe dark.- Male genitalia: aedeagus with mesophallus long, slender as in figure enclosed (SPENCER, 1976a: 271).

Distribution: Palaearctic: Austria, Belgium, Britain I., Czech Republic, Danish mainland, Finland, French mainland, Germany, Hungary, Ireland, Italian mainland, Lithuania, Norwegian mainland, Poland, Slovakia, Spanish mainland, Sweden, The Netherlands; East Palaearctic; Near East; Nearctic region; North Africa; Oriental region.

Host-plants: *Conyza, Euphorbia, Eryngium, Lapsana, Lepidium, Picris, Sonchus.*

It presents a high specificity in Europe on *Sonchus*, and forms slightly elongated blotch mines.

Phenology: It has been captured punctually in spring in "Lagunas de La Mata-Torrevieja" with average temperatures of 19ºC (23ºC max. and 15ºC min.).

Liriomyza trifolii (Burgess in Comstock, 1880)

= *Liriomyza alliovora* Frick, 1955
= *Agromyza phaseolunulata* Frost, 1943

Material examined: Tinença de Benifassà: 1♂, 14-21.x.2004; 1♂, 10-17.vii.2006; Lagunas de La Mata-Torrevieja: 1♂, 19-24.x.2004; 1♂, 14-21.xii.2004; 1♂, 15-22.xi.2005; 2♂, 19-26.ix.2006; 1♂, 31.x.2006-7.xi.2006; 1♂, 14-21.xi.2006; 1♂, 21-

28.xi.2006; 2♂, 28.xi.2006-5.xii.2006; 3♂, 20.ii.2007-6.iii.2007; 2♂, 27.iii.2007-3.iv.2007; 4♂, 10-17.iv.2007; 3♂, 17-24.iv.2007; 3♂, 24.iv.2007-1.v.2007; 3♂, 1.v.2007-8.v.2007; 2♂, 8-16.v.2007.

Diagnostic characters: Small species with conspicuously mat greyish mesonotum and both vertical bristles on yellow ground; orbits entirely yellow, black of occiput approaching and frequently reaching eye margin beyond outer vertical bristle; all antennal segments bright yellow, third only finely pubescent; thorax blackish-grey, entirely mat, acrostichals in 3 or 4 rows in front, reduced to two rows behind, conspicuous yellow patch at each hind-corner of mesonotum adjoining scutellum; mesopleura with small blackish-grey patch on lower margin, sternopleura largely black, upper margin yellow; legs with coxae yellow, femora largely so but with slight, variable brownish striation; tibiae and tarsi darker, brown. Male genitalia.- Aedeagus as in SPENCER, 1976a: 231. Distiphallus distinctly constricted apically, neck behind adjoining and relatively long, little shorter than distiphallus proper; epiphallus conspicuously narrowing distally; surstyli with single spine at end.

Distribution: Palaearctic: Austria, Belgium, Britain I., Bulgaria, Canary Is., Corsica, Crete, Cyprus, Czech Republic, Danish mainland (doubtful), European Turkey, Finland, French mainland, Germany, Greek mainland, Hungary, Ireland, Italian mainland, Malta, Monaco, Norwegian mainland, Poland, Portuguese mainland, Romania, Sardinia, Sicily, Slovakia, Slovenia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; Afro-tropical region; Australian region; East Palaearctic; Near East; Nearctic region; Neotropical region; North Africa; Oriental region.

Host-plants: *Abelmoschus, Ageratum, Agrimonia, Ajuga, Allium, Alstroemeria, Amaranthus, Ambrosia, Anemone, Anethum, Anthriscus, Antirrhinum, Apium, Arachis, Arctium, Artemisia, Asclepias, Aster, Avena, Baccharis, Basella, Bellis, Beta, Bidens, Brachycome, Brassica, Bryonia, Cajanus, Callistephus, Callistephus, Canavalia, Capraria, Capsella, Capsicum, Cardiospermum, Carthamus, Cassia, Celosia, Centaurea, Centranthus, Cestrum, Chelone, Chenopodium, Chrysanthemum, Cirsium, Citrullus, Conoclinium, Convolvulus, Conyza, Crataegus, Crotalaria, Cucumis, Cucurbita, Dahlia, Datura, Daucus, Dendranthema, Dianthus, Dimorphotheca, Erechtites, Erigeron, Eupatorium, Fallopia, Flaveria, Fuchsia, Gaillardia, Galinsoga, Gazania, Gerbera, Gladiolus, Glycine, Gnaphalium, Gossypium, Gypsophila, Helianthus, Helichrysum, Hibiscus, Holmskioldia, Hordeum, Hydrocotyle, Hymenopappus, Ipomoea, Kallstroemia, Lactuca, Lamium, Lannea, Lantana, Lathyrus, Launaea, Leucanthemum, Linaria, Lycopersicon, Medicago, Melilotus, Moluccella, Momordica, Nepeta, Ocimum, Passiflora, Pastinaca, Peperomia, Peristrophe, Petroselinum, Petunia, Phaseolus, Phlox, Piper, Pisum, Plantago, Polygonum, Portulaca, Primula, Pupalia, Ranunculus, Raphanus, Ricinus, Rumex, Ruspolia, Salvia, Scaevola, Senecio, Solanum, Solidago, Sonchus, Spilanthes, Spinacia, Stellaria, Synedrella, Tagetes, Tanacetum, Taraxacum, Thlaspi, Tithonia, Trachelium, Tragopogon, Tribulus, Tridax, Trifolium, Trigonella, Tropaeolum, Typha, Verbena, Vernonia, Vicia, Vigna, Withania, Xanthium, Zinnia.*

Liriomyza trifolii was described from Washington, and is now known as one of the most polyphagous species in the Agromyzidae, with records from 25 families. It has also developed a greater degree of resistance to insecticides than any other species and has been introduced widely to many countries, primarily with infested *Chrysanthemum* cuttings. Its genitalia is really close to *L. sativae* Blanchard, 1938, with adults differing in colour.

Phenology: It has been captured in summer and autumn in "Tinença de Benifassà" with average temperatures of 22-24.5ºC (31ºC max. and 15ºC min.). In "Lagunas de La Mata-Torrevieja" it is widely present in practically all seasons when the temperature is moderate due to the presence of greenhouses near the Natural Park lagoons. Maximum captures were produced with average temperatures of 15.5ºC (19ºC max. and 12ºC min.) (Fig. 5-82).

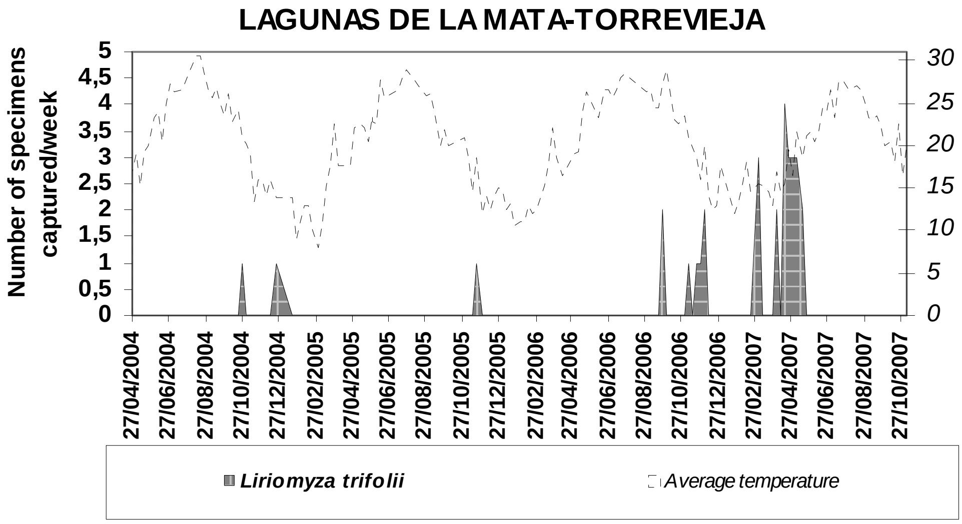


Figure 5-82. Space-time captures evolution of *Liriomyza trifolii* (Burgess in Comstock 1880) males in Natural Park of "Lagunas de La Mata-Torrevieja".

5.3.2.7 Genus ***Metopomyza*** Enderlein, 1936

Metopomyza genus is composed of 14 species in the Palaearctic region. In Spain, MARTINEZ (2004) cites the presence of 2 species, *Metopomyza flavonotata* (Haliday, 1833) and *Metopomyza xanthaspis* (Loew, 1858). Later, CERNY & MERZ (2006) reported the presence of *Metopomyza scutellata* (Fallén, 1823). In this way, *Metopomyza* genus is composed of 3 species in Spain.

Key diagnostic characters: Orbits normal, separated throughout by the frons; orbital setulae erect, reclinate or absent; wing with costa extending to apex of vein M_{1+2}; scutellum yellow and vein M_{1+2} nearest wing tip; orbits broad, raised above plane of frons; frons dark; stridulating mechanism lacking in male.

Known host-plants families from the *Metopomyza* genus are Cyperaceae, Graminae and Juncaceae (BENAVENT-CORAI *et al.*, 2005a).

***Metopomyza scutellata* (Fallén, 1823)**

Material examined: Tinença de Benifassà: 1♂, 8-15.vii.2004; 1♂, 26.vi.2006-3.vii.2006.

Diagnostic characters: Minute species with yellow knees. Frons brownish-ochrous above, more black towards lunule; orbits broad, shining black; mesonotum moderately shining black, with at most 3 differentiated *dc*; legs black but femora with all knees distinctly yellow; squamae whitish or pale grey, margin and fringe brown; wing length 1.2 to 1.6 mm, discal cell small, last section of M_{3+4} at least 3 times length of penultimate; second cross vein rarely lacking.- Male genitalia: aedeagus as in SPENCER, 1976a: 286, with distal tubules short and mesophallus conspicuously narrow; surstyli elongate, divided apically, epandrium with 2 areas of chitinization, each bearing short with strong spines.

Distribution: Palaearctic: Belarus, Britain I., Czech Republic, Danish mainland, Estonia, Finland, French mainland, Germany, Hungary, Lithuania, Poland, Slovakia, Sweden, Yugoslavia.

Host-Plants: *Carex.*

Two species in the *Metopomyza* genus are known to feed on *Carex*. *Metopomyza scutellata* was reared by Groschke (1954) from a narrow linear mine on *Carex sylvatica* Huds. in Southern Germany. The other species is *Metopomyza xanthaspis* (Loew, 1858) with a distinct genitalia. Other species in this genus are known to feed on grasses.

Phenology: It is present in "Tinença de Benifassà" in summer with average temperatures of 20-24.5ºC (33ºC max. and 14ºC min.).

5.3.2.8 Genus ***Napomyza*** Westwood, 1840

Napomyza genus is composed of 42 species in the Palaearctic region. MARTINEZ (2004) cites the presence of 33 species in Europe and 6 species in Spain. The fauna of continental spanish is composed of *Napomyza carotae* Spencer 1966, *Napomyza cichorii* Spencer 1966, *Napomyza hirticornis* (Hendel 1932), *Napomyza lateralis* (Fallén 1823), *Napomyza scrophulariae* Spencer 1966 and *Napomyza tripolii* Spencer 1966.

Most species included in this genus are internal stem-borers. They have their frons and orbits conspicuously projecting. The second costal section is short and the second cross-vein is present. Later some other leaf-mining species with the second cross-vein present and included in this genus were transferred to *Phytomyza* genus (SPENCER, 1976b). At present, there is still confusion at this time to discern whether certain species belong to the genus *Napomyza* or *Phytomyza*. Molecular biology seems to be the way that could clarify the systematics of these two close genera.

Key diagnostic characters: orbits normal, separated throughout by the frons; orbital setulae distinctly proclinate; costa extending only to vein R_{4+5}; second cross-vein frecuently present, close to first; if absent, remnant of 8^{th} sternite present, adjoining 8^{th} tergite; frons normally greatly projecting above eye (SPENCER, 1976b).

Essential characters cited by SPENCER (1976b) about the post-abdomen of *Napomyza* are: the 8^{th} sternum normally present, partially fused with the 6^{th}-8^{th} tergites; elongate surstyli showing a clear line of fusion with the epandrium and in some species extending free within the epandrium; conspicuous strong, elongate postgonites with well-defined spine or hook at ventral end; the characteristic aedeagus, particularly the distiphallus; and the tapering yellow puparium.

Known host-plants families of *Napomyza* genus cited by BENAVENT-CORAI *et al.* (2005a) are 9: Campanulaceae, Compositae, Gramineae, Labiatae, Leguminosae, Linaceae, Ranunculaceae, Scrophulariaceae and Umbelliferae.

Napomyza lateralis (Fallén, 1823)

Material examined: Tinença de Benifassà: 2♂, 20-27.v.2004; 1♂, 3-10.vi.2004; 5♂, 10-17.vi.2004; 1♂, 25.vi.2004-1.vii.2004; 1♂, 8-15.vii.2004; 3♂, 15-22.vii.2004; 1♂, 22-29.vii.2004; 6♂, 29.vii.2004-5.viii.2004; 1♂, 12-19.viii.2004; 1♂, 16-23.ix.2004; 1♂, 16-23.v.2005; 1♂, 6-13.vi.2005; 1♂, 3-10.x.2005; 1♂, 6-17.iv.2006; 1♂, 17-24.iv.2006; 3♂, 24.iv.2006-1.v.2006; 4♂, 8-15.v.2006; 11♂, 15-22.v.2006; 30♂, 22-29.v.2006; 5♂, 29.v.2006-5.vi.2006; 1♂, 5-12.vi.2006; 1♂, 3-10.vii.2006; 1♂, 10-17.vii.2006; 1♂, 12-23.x.2006; 1♂, 12-20.iii.2007; Font Roja: 1♂, 10-17.vi.2004.

Diagnostic characters: Head with frons broad, twice width of eye, conspicuously projecting eye in profile; 2 *ors* and 2 *ori*, orbital setulae proclinate; jowls deep, ½ vertical height of eye, cheeks forming broad ring below eye; third antennal segment slightly longer than broad, virtually bare; wing length from 2.5 mm in male to 3 mm in female; second cross-vein normally in direct continuation of first; colour: frons bright yellow, hind-margin of eye black, both *vt* on black ground, all antennal segments black; mesonotum and scutellum ash-grey, pleura somewhat darker black; femora black, yellow at knees; squamal fringe black.- Male genitalia: aedeagus as in SPENCER, 1976b: 339.

Distribution: Palaearctic: Austria, Azores, Belarus, Belgium, Britain I., Canary Is., Czech Republic, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Greek mainland, Hungary, Ireland, Italian mainland, Latvia, Lithuania, Madeira, Poland, Sicily, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; East Palaearctic (doubtful); Near East; Nearctic region; North Africa.

Host-Plants: *Anthemis, Bellis, Bidens, Calendula, Carduus, Centaurea, Cirsium, Crepis, Helichrysum, Hypochaeris, Inula, Lactuca, Linum, Lupinus, Matricaria, Senecio.*

Napomyza lateralis is a highly oligophagous and crosses tribal boundaries, but with numerous misidentifications in the past. This species have a close similarity to a group of species on Asteraceae. Revisionary work will be necessary to accurately establish the host-plants of the true *N. lateralis*, described originally from a single captured specimen in Sweden.

Phenology: It is present in spring, summer and autumn in “Tinença de Benifassà” with a minimum of 3 generations/year. Maximum captures were produced in the last week of May with 30 males, when average temperatures were of 23ºC (30ºC max. and 16ºC min.). In “Font Roja”, captures were produced punctually in June with average temperatures of 21ºC (27.9ºC max. and 14ºC min.) (Fig. 5-83).

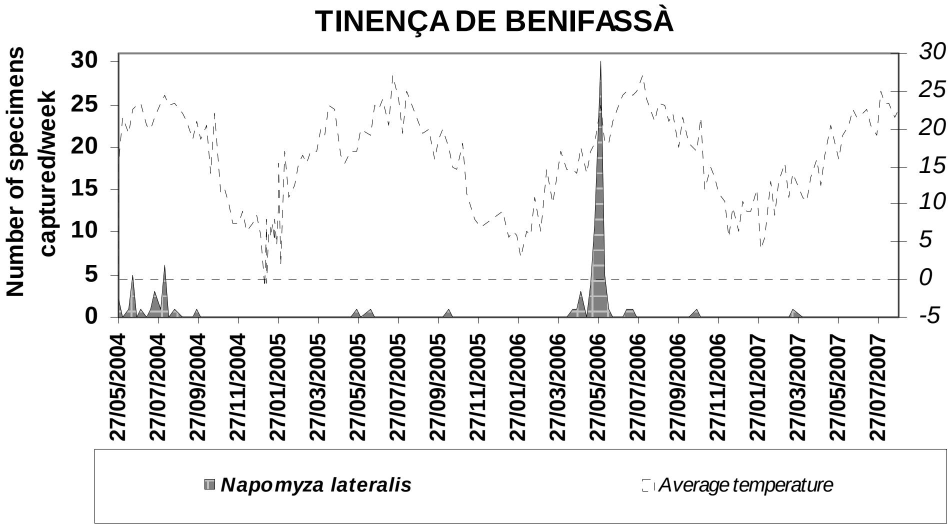


Figure 5-83. Space-time captures evolution of *Napomyza lateralis* (Fallén, 1823) males in Natural Park of "Tinença de Benifassà".

5.3.2.9 Genus ***Phytobia*** Lioy, 1864

Phytobia genus is composed of 17 species in the Palaearctic region. MARTINEZ (2004) cites the presence of 9 species in Europe. In the present thesis is cited 2 new records from Spain, *Phytobia cerasiferae* (Kangas, 1955) and *Phytobia lunulata* (Hendel, 1920), thus reaching the figure of 4 known species.

Phytobia is restricted to large cambium-borers species feeding internally in stems and trunks of trees (SPENCER, 1976a).

Key diagnostic characters: orbital setulae erect or reclinate; pre-sutural *dc* strongly developed; pre-scutellars present; scutellum concolorous with mesonotum (in European species); large species, wing length from 3 to 4.5 mm; costa normally extending to vein M_{1+2} (except in one European and one North American species) (SPENCER, 1976a).

Known host-plants families of *Phytobia* genus is concluded by BENAVENT-CORAI *et al.* (2005a): Aceraceae, Betulaceae, Fagaceae, Rosaceae and Salicaceae.

***Phytobia carbonaria* (Zetterstedt, 1848)**

= *Dizigomyza latigenis* Hendel, 1931
= *Agromyza nigra* Zetterstedt, 1838

Material examined: Font Roja: 1♂, 29.v.2006-5.vi.2006.

Diagnostic characters: Frons mat black, frecuently more brownish in front, broad, twice width of eye, conspicuously projecting above eye in profile; normally 2 reclinate *ors* and 4 more incurved *ori*, orbital setulae reclinate; lunule semicircular, jowls ¼ height of eye, cheeks forming broad ring below eye; third antennal segment large, rounded, blackish-brown; mesonotum black, slightly shining, with 3+1 strong *dc*; wing length 4-4.2 mm, costa ending to vein M_{1+2}, last and penultimate sections of M_{3+4}

approximately equal; wing base reddish-brown, squamae pale grey, margin and fringe black.- Male genitalia: aedeagus as in SPENCER, 1976a: 154.

Distribution: Palaearctic: Austria, Belgium, Britain I., Danish mainland, French mainland, Germany, Hungary, Norwegian mainland, Poland, Spanish mainland, The Netherlands.

Host-plant: *Crataegus, Malus.*

Phytobia carbonaria feeds on *Crataegus* and *Malus* in Europe.

Phenology: It has been captured in "Font Roja" at the beginning of summer.

Phytobia errans (Meigen, 1830)

Material examined: Font Roja: 1♂, 15-22.vii.2004.

Diagnostic characters: Frons sooty black, twice width of eye, not significantly projecting above eye; 2 *ors* and 2 *ori*; orbital setulae sparse, reclinate; ocellar triangle ill-defined, scarcely shining, lunule semicircular, pale grey; jowls narrow, deepest at rear, 1/7 height of eye; antennal segments black, third ovoid, arista inconspicuously pubescent, mesonotum largely mat, greyish-black, with 3+1 strong *dc*, *prsc* well-developed; wing length from 3.2 to 3.6 mm, costa extending strongly to vein M_{1+2}, last section of M_{3+4} 1 ½ times length of penultimate; squamae pale grey, margin and fringe black.- Male genitalia: aedeagus as in SPENCER, 1976a: 155, with distiphallus ending in 2 long tubules.

Distribution: Palaearctic: Austria, Britain I., Danish mainland, French mainland, Germany, Hungary, Italian mainland, Spanish mainland, The Netherlands.

Host-plants: Unknown.

Phenology: It has been captured punctually in "Font Roja" in summer when the average temperatures range is 25.6ºC (34.3ºC max. and 16.9ºC min.).

5.3.2.10 Genus ***Phytoliriomyza*** Hendel, 1931

Phytoliriomyza genus is composed of 20 species in the Palaearctic region. In Europe, Martinez (2004) cited 19 species, and 4 in Spain. Later, the spanish biodiversity was up-dated by the additions of *Phytoliriomyza dorsata* (Siebke, 1864) (ZLOBIN, 2005) and *Phytoliriomyza immoderata* Spencer, 1963 (CERNY & MERZ, 2006).

SPENCER (1976a) cites *Phytoliriomyza* genus as a subgenus of *Liriomyza*. The essential difference is the presence of orbital setulae entirely proclinate. The scutellum is normally at least centrally yellow but may be entirely grey and the halteres can be somewhat darkened. Its close proximity to genus *Metopomyza* is also observed, suggesting the existence of species belonging to *Phytoliriomyza* within this genus.

Key diagnostic characters: orbits normal, separated throughout by the frons; orbital setulae erect, reclinate or absent; wing costa extending to apex of vein M_{1+2}; scutellum yellow; vein M_{1+2} nearest wing tip; orbits largely in plane of frons; frons yellow; stridulating mechanism lacking; prescutellar area yellow; orbital setulae normally upright or slightly proclinate, rarely slightly reclinate; epandrium with a conspicuous comb-like arrangement of black spines internally or a patch of strong bristles on lower hind-corner of epandrium.

BENAVENT-CORAI *et al.* (2005a) cites the known host-plants families of *Phytoliriomyza* genus: Aspleniaceae, Balsaminaceae, Bignoniaceae, Butomaceae, Compositae, Cyatheaceae, Dennstaedtiaceae, Dryopteridaceae, Grammitidaceae, Leguminosae, Pittosporaceae, Polypodiaceae, and Solanaceae.

Phytoliriomyza arctica (Lundbeck, 1901)

= *Agromyza formosensis* Malloch, 1914
= *Agromyza halterata* Becker, 1908
= *Odinia immaculata* Coquillett, 1902
= *Phytoliriomyza montana* Frick, 1953

Material examined: Tinença de Benifassà: 1♂, 20-27.v.2004; 2♂, 27.v.2004-3.vi.2004; 1♂, 10-17.vi.2004; 1♂, 8-15.vii.2004; 1♂, 13-20.vi.2005; 2♂, 6-17.iv.2006; 1♂, 17-24.iv.2006; 1♂, 24.iv.2006-1.v.2006; 4♂, 15-22.v.2006; 7♂, 22-29.v.2006; 2♂, 5-12.vi.2006; 1♂, 3-10.vii.2006; 1♂, 10-17.vii.2006; 3♂, 5-12.ii.2007; 1♂, 26.ii.2007-5.iii.2007; 1♂, 20.iii.2007-2.iv.2007; 1♂, 16-23.iv.2007; 1♂, 23-30.iv.2007.

Diagnostic characters: head with 2 equal, reclinate *ors*, 1 incurved *ori*, orbital setulae distinctly proclinate; eye slanting, frecuently pilose; third antennal segment large, round; mesonotum with 3+1 strong *dc*, *acr* sparse, in 2 rows; wing length from 1.6-2.2 mm, costa extending strongly to vein M_{1+2}, last section of M_{3+4} approx. 1 ½ times length of penultimate, always less than 2 times; colour highly variable with frons, pleura and legs almost completely black; frons normally yellowish-brown with orbits slightly paler, third antennal segment yellowish, darker brown on outside or generally darker; mesonotum mat grey, scutellum similar or faintly yellow centrally; mesopleura normally yellow, with black bar on lower margin; femora yellow, with variable brownish striations; halteres yellow normally distinctly darkened at top.- Male genitalia: aedeagus ending in long, membranous and coiled tubules as in SPENCER, 1976a: 293; surstyli with only a few weak hairs internally, epandrium without strongly chitinised structures as in *dorsata* and *melampyga* groups.

Distribution: Palaearctic: Balearic Is., Britain I., Canary Is., Czech Republic, Danish mainland, European Turkey, Finland, French mainland, Germany, Greek mainland, Hungary, Italian mainland, Lithuania, Madeira, Poland, Sicily, Spanish mainland, Switzerland, Yugoslavia; Afro-tropical region; Australian region; East Palaearctic; Nearctic region; Neotropical region; Oriental region.

Host-plants: *Crepis, Lapsana, Solidago, Sonchus.*

It has been recorded as a stem miner. Due to its almost cosmopolitan distribution of species, it seems certain that it has other host-plants. It was discovered in Greeland and it has been dispersed throughout Europe, Sri Lanka, Taiwan, and has close relatives in Australia and New Zealand. Such a distribution clearly indicates an ancient species that supports the theory that *Phytoliriomyza* is a primitive genus.

Phenology: It has been found from the beginning of spring until late summer in "Tinença de Benifassà". It normally presents 4 generations registered from the end of winter to mid-summer. Maximum captures were 7 males/week with average temperatures of 23ºC (30ºC max. and 16ºC min.) (Fig. 5-84).

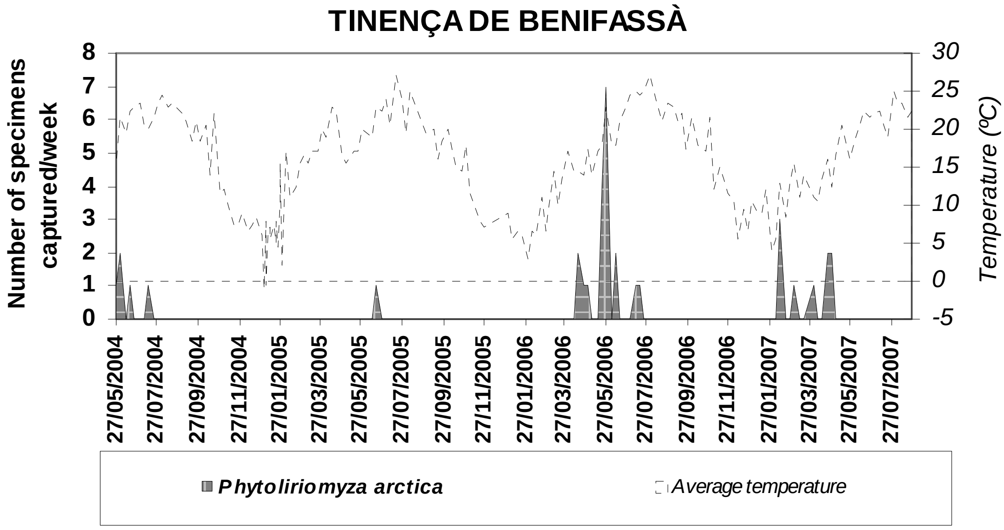


Figure 5-84. Space-time captures evolution of *Phytoliriomyza arctica* (Lundbeck, 1901) males in Natural Park of "Tinença de Benifassà".

Phytoliriomyza perpusilla (Meigen, 1830)

= *Agromyza flaviventris* Strobl, 1910 Preocc.; as subsp. of *Agromyza perpusilla*.

Material examined: Tinença de Benifassà: 1♂, 24.vii.2006-1.viii.2006; 1♂, 20-28.viii.2006; 1♂, 12-23.x.2006; Font Roja: 1♂, 3-10.vi.2004; 1♂, 9-16.viii.2004; 1♂, 18-25.ix.2006.

Diagnostic characters: Frons broad, almost twice width of eye, not projecting above eye in profile; 2 reclinate *ors*, the lower weaker than the upper, a single inclined *ori*; orbital setulae regularly reclinate; eye slanting; third antennal segment large, ovoid, with short, normal pubescence; arista long, drooping; mesonotum with 3+1 *dc*, *acr* in 2 rows or lacking; wing length 1.5-1.75 mm, costa extending strongly to vein M_{1+2}, second cross-vein characteristically slanting, discal cell small, last section of M_{3+4} twice penultimate; colour: head largely yellow, frons sometimes orange-brown, constrasting with the paler orbits; first and second antennal segments yellow, third variable, from yellow to blackish, at least on outside; mesonotum mat grey, scutellum either similar or faintly yellowish centrally; pleura largely yellow to mesopleura with small black bar on lower margin; legs: variable, from almost completely yellow to largely black, though with some yellow undertone; abdomen blackish-grey but tergites frecuently yellow laterally; halteres yellow but with pale brownish-black area above.- Male genitalia: aedeagus ending in 2 short, asymmetrical tubules as in SPENCER, 1976a: 303; ninth sternite with slender side-arms and U-shaped; surstyli elongate, with several strong hairs at end.

Distribution: Palaearctic: Austria, Belgium, Britain I., Bulgaria, Canary Is., Czech Republic, Estonia, Finland, French mainland, Germany, Greek mainland, Hungary, Lithuania, Poland, Spanish mainland, Sweden, The Netherlands; North Africa.

Host-plant: Unknown.

Phenology: It has been captured in summer in "Tinença de Benifassà", and also in summer and autumn in "Font Roja". In "Tinença de Benifassà" the average temperature range of captures were 18-25.3ºC (36.4ºC max. and 13.6ºC min.), and in "Font Roja" 17-27ºC (32ºC max. and 12ºC min.). Captures were produced very uniformly without exceeding of 1 males/week.

5.3.2.11 Genus ***Phytomyza*** Fallén, 1810

Phytomyza genus is composed of 330 species in the Palaearctic region representing 50% of known Agromyzidae species. MARTINEZ (2004) cites the presence of 282 species in Europe, and 45 in Spain. Later, it was reported two new species *Phytomyza hellebori* Kaltenbach, 1872 (CERNY & MERZ, 2006) and *Phytomyza petoei* Hering, 1924 (CERNY & VALA, 2006). In this thesis the number of known *Phytomyza* species from continental Spain has been updated to 49, adding *Phytomyza bupleuri* Hering, 1963 and *Phytomyza tanaceti* Hendel, 1923.

Historical characters defining this genus are the proclinate orbital setulae, the termination of the costa at vein R_{4+5}, and the lack of the cross-vein. But now there are many species in this genus that do not accomplish the cited characteristics. Many monophyletic groups rigidly associated with a specific plant genus, family or group of families are detected. *Phytomyza* includes species showing a great diversity in head shape, colour, size, male genitalia; and also in larval characters, and the colour and shape of the puparium. SPENCER cites the probable proposition for future workers of subgeneric or even separate generic status for some of the monophyletic groups based on their host association and specific genitalia. Adults can only be identified as genus if the host is known or after examining male genitalia, being impossible to give even a generic placing to females captured (SPENCER, 1976b). *Phytomyza* genus is very close to *Napomyza* and *Chromatomyia*, and now it exists important doubts about the location of certain species.

At present the studies carried out by WINKLER *et al.* (2009) have reshaped the position of the *Chromatomyia*, *Napomyza* and *Ptochomyza* genera, going to be included as subgenera within *Phytomyza*. Sequencing and phylogenetic study of CAD, COI and PGD genes for 113 species belonging to the above cited genera have recunfigured the *Phytomyza* genus in the following way: *Phytomyza* subgenus *Napomyza* (*annulipes* group, *elegans* group and *lateralis* group), *Phytomyza* subgenus *Ptochomyza*, *Phytomyza* sensu stricto (subgenus *Phytomyza*) (*spoliata* group, *minuscula* group, *ciliata* group, *robustella* group, *syngenesiae* group, *hendeli* group, *loewii* group, *angelicae* group, *spondylii* group, *albiceps* group, *petoei* group, *rufipes* group, *notata* group, *anemones* group, *albipennis* group, *ranunculella* group, *atomaria* group, *ilicis* group, *agromyzina* group, *opaca* group, *obscura* group, *aquilegiae* group, *buhriana* group and *knowltoniae* group) and unplaced species. However, this thesis follows the traditional classification due to this results have been published at the end of this study and possibly could be modified because they are presented as preliminary results.

Key diagnostic characters: orbits normal, separated throughout by the frons; orbital setulae distinctly proclinate; costa extending to vein R_{4+5}; second cross-vein normally absent, if present, frons not proyecting and second costal section at least 2 ½ times length of fourth (SPENCER, 1976b).

The number of known host-plants of *Phytomyza* includes a lot of families summarised by BENAVENT-CORAI *et al.* (2005a): Alliaceae, Aquifoliaceae, Araliaceae, Balsaminaceae, Boraginaceae, Campanulaceae, Caprifoliaceae, Compositae, Cornaceae, Crassulaceae, Cruciferae, Fagaceae, Globulariaceae, Gramineae, Hydrangeaceae, Hydrophyllaceae, Labiatae, Lardizabalaceae, Leguminosae, Oleaceae, Orobanchaceae, Papaveraceae, Plantaginaceae, Ranunculaceae, Rhamnaceae, Rosaceae, Scrophulariaceae, Solanaceae, Styracaceae, Umbelliferae, and Urticaceae.

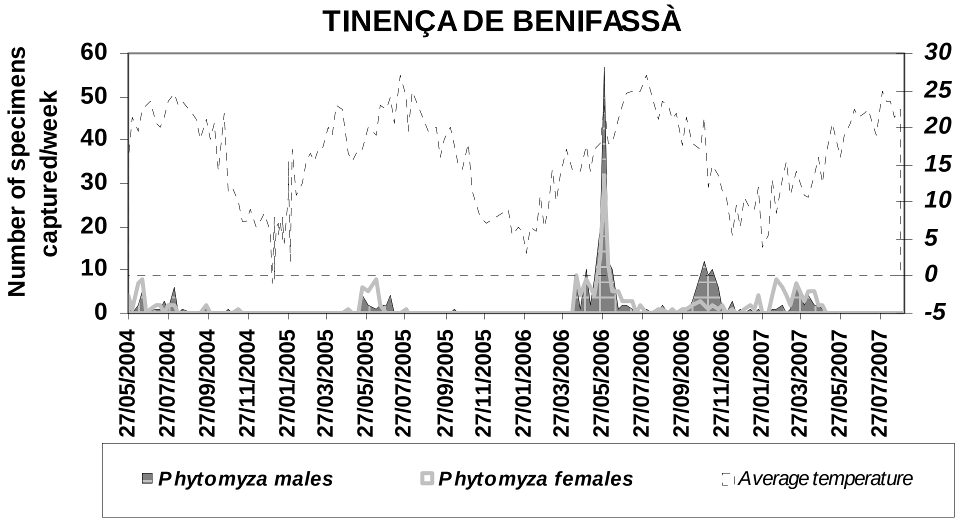


Figure 5-85. Space-time captures evolution of *Phytomyza* genera in Natural Park of "Tinença de Benifassà".

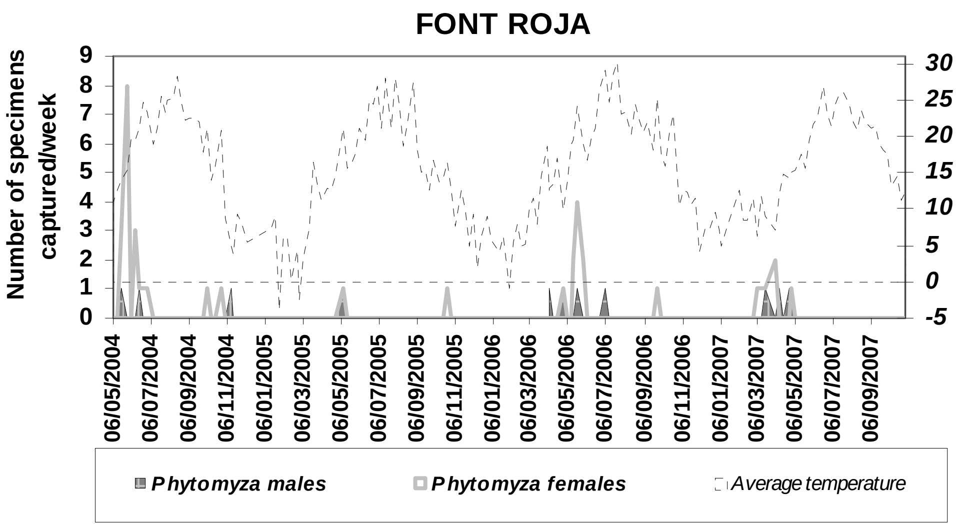


Figure 5-86. Space-time captures evolution of *Phytomyza* genera in Natural Park of "Font Roja".

Phenology dynamics of the *Phytomyza* group (includes *Phytomyza* and *Napomyza* genera) in the “Tinença de Benifassà” Natural Park is resumed in the Fig. 5-85. The year 2006 presents 4-5 generations distributed from spring to late autumn. The main generation was produced in spring with an important peak registered with 57 males and 32 females/week. Average temperatures present throughout the period of maximum captures were of 23ºC (30ºC max. and 16ºC min.). Autumn shows on almost exclusive presence of males with a maximum of 12 males/week (sex-ratio equal to 6). Seasonal captures between different years is strongly influenced by environmental conditions, where captures in 2004 and 2005 are very low. In “Font Roja” captures were very irregular throughout the years studied showing a higher presence of females than males. The number of generations registered is also around 4-5 per year with maximum captures of 4 females/week registered in spring when average temperature ranges were of 19.4ºC (24ºC max. and 14.7ºC). Male captures were very constant and low with maximum captures of 1 males/week (Fig. 5-86). In “Lagunas de La Mata-Torrevieja” captures were continuous from autumn to the end of spring when high temperatures were moderate. The number of generations registered in this period was 7. Maximum captures registered were 7 males/week with average temperatures of 15ºC (22ºC max. and 8.1ºC min). When high temperatures are upper than 30-35ºC captures are null, also conditioned by low rainfall and humidity (Fig. 5-87).

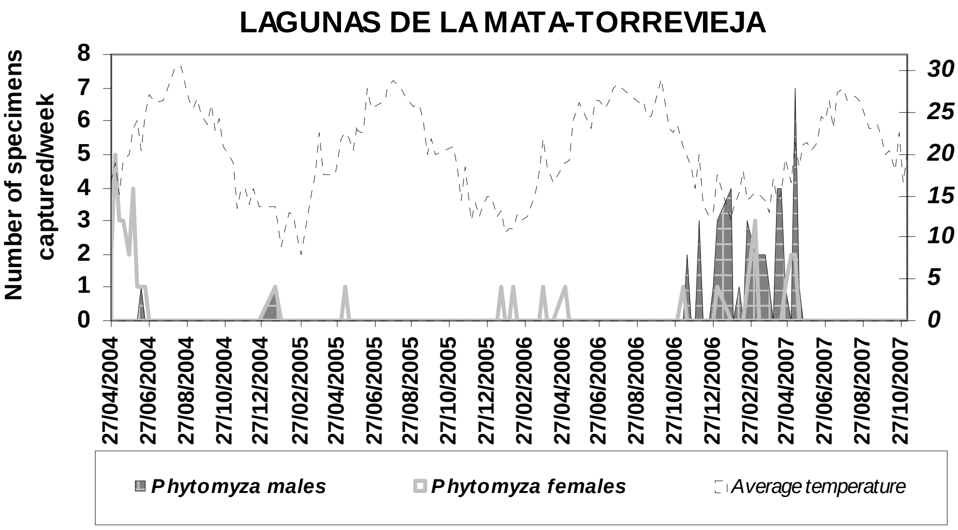


Figure 5-87. Space-time captures evolution of *Phytomyza* genera in Natural Park of “Lagunas de La Mata-Torrevieja”.

Phytomyza albipennis Fallén, 1823

Material examined: Tinença de Benifassà: 1♂, 5-12.vi.2006.

Diagnostic characters: Frons broad, orbits conspicuously projecting above eye in profile; 2 equal reclinate *ors*, 2 or 3 long, slender, incurved *ori*; jowls broad, 2/5 height of eye, cheeks filling half distance between eye margin and lower margin of jowls; third antennal segment longer than broad, arista swollen at base, fine, appearing almost bare on distal two thirds; conspicuous epistoma above mouth margin; proboscis elongate; 3+1 strong *dc*, *acr* irregularly in 4 rows; wing length 2.5-2.9 mm, second costal section 1 ¾ - 2 times length of fourth, second cross vein lacking; colour of frons dark brown or black, orbits and cheeks conspicuously paler, greyish-yellow; lunule grey or yellowish; jowls and face brownish-black, all antennal segments black; mesonotum mat, almost silvery-grey; sides of thorax greyish-black, upper margin of mesopleura only narrowly yellow; legs black, knees yellowish on *p1* but only indistinctly so on *p2* and *p3* ; wings silvery-white, only veins R_2 and R_3 darkened, brownish, others colourless; squamae yellowish-grey, margin orange, fringe yellow to ochrous.- Male genitalia: aedeagus as in SPENCER, 1976b: 333; 8th sternum present, narrow and strongly chitinized ventrally; surstyli slightly extended ventrally.

Distribution: Palaearctic: Austria, Belgium, Britain I., Canary Is., Channel Is., Croatia, Czech Republic, Danish mainland, Estonia, Finland, French mainland, Germany, Hungary, Italian mainland, Lithuania, Poland, Slovakia, Spanish mainland, Sweden, The Netherlands, Yugoslavia.

Host-plants: *Ranunculus.*

It is a distinctive species with silvery-white wings, known only in Europe with a genitalia clearly associated with *Phytomyza evanescens* Hendel, 1920.

Phenology: It has been found punctually in “Tinença de Benifassà” at the beginning of June with average temperatures of 16.6ºC (21.3ºC max. and 11.8ºC min.).

Phytomyza clematidis Kaltenbach, 1859

= *Phytomyza mallorcensis* Spencer, 1969

Material examined: Tinença de Benifassà: 1♂, 6-13.xi.2006.

Diagnostic characters: KALTENBACH, 1859: 267.

Distribution: Palaearctic: Balearic Is., Britain I., Dodecanese Is., European Turkey, French mainland, Germany, Hungary, Italian mainland, Lithuania, Malta, Spanish mainland, Switzerland, The Netherlands.

Host-plants: *Clematis, Ranunculus.*

P. clematidis feeds on flower-heads and stems. Its genitalia have a characteristic form, previously noted in species from Africa, Australia and New Zealand on *Ranunculus*.

Phenology: It has been found punctually in “Tinença de Benifassà” in autumn with average temperatures of 12.6ºC (17.5ºC max. and 7.8ºC min.).

Phytomyza crassiseta Zetterstedt, 1860

= *Phytomyza atomaria* Zetterstedt, 1848
= *Phytomyza veronicae* Kaltenbach, 1873

Material examined: Tinença de Benifassà: 1♂, 3-10.vi.2004; 1♂, 13-20.vi.2005; 1♂, 24.iv.2006-1.v.2006; 1♂, 1-8.v.2006; 2♂, 8-15.v.2006; 2♂, 15-22.v.2006; 13♂, 22-29.v.2006; 6♂, 29.v.2006-5.vi.2006; 2♂, 5-12.vi.2006; 1♂, 19-26.vi.2006; 1♂, 4-

11.xii.2006; <u>Font Roja</u>: 1♂, 13-20.v.2004; 1♂, 20-27.iv.2006; 1♂, 15-22.v.2006; 1♂, 12-19.iii.2007; 1♂, 2-9.iv.2007; 1♂, 16-25.iv.2007; 1♂, 25-30.iv.2007.

Diagnostic characters: Frons narrowly projecting above eye, particularly towards base of antennae; 2 equal *ors*, 1 or 2 *ori*; jowls broad, 1/3 height of eye, cheeks forming broad ring below eye; third antennal segment large, arista conspicuously broadening; 3+1 strong *dc*, *acr* sparse, in 2 rows; wing length up to 2 mm, second costal section short, 1 ½-2 times length of fourth; colour: frons, jowls and face bright yellow; hind-margin of eye black, with both *vt* normally on dark ground, orbits generally darkened to lower *ors*, third antennal segment black, second varying from greyish to somewhat yellowish; mesonotum mat, ash-grey, sides of thorax dark but upper margin of mesopleura narrowly yellow; legs: fore-coxae yellow, femora black, with yellowish knees; abdomen black; squamae yellow, margin and fringe dark, brownish.- Male genitalia: aedeagus as in SPENCER, 1976b: 409.

Distribution: Palaearctic: Belarus, Britain I., Canary Is., Czech Republic, Danish mainland, Estonia, Finland, French mainland, Germany, Hungary, Ireland, Italian mainland, Latvia, Lithuania, Norwegian mainland, Poland, Romania, Spanish mainland, Sweden, The Netherlands; East Palaearctic; Nearctic region; Neotropical region.

Host-plants: *Veronica.*

It occurs commonly in the genus *Veronica* in Europe, and is also present in the United States and Chile as an introduction. Pupation takes place in the leaf that clearly facilitates the chance introduction. The male genitalia show the close relationship with *Phytomyza veronicicola* Hering, 1925 which is only known in Europe. In *Phytomyza crassiseta* the arista is conspicuously thickened but is normal in *P. veranicicola*. However, in *Phytomyza digitalis* Hering, 1925 the arista has the same apomorphic form as in *P. crassiseta* but the genitalia indicate that these two species are less closely related than the two feeders on *Veronica*.

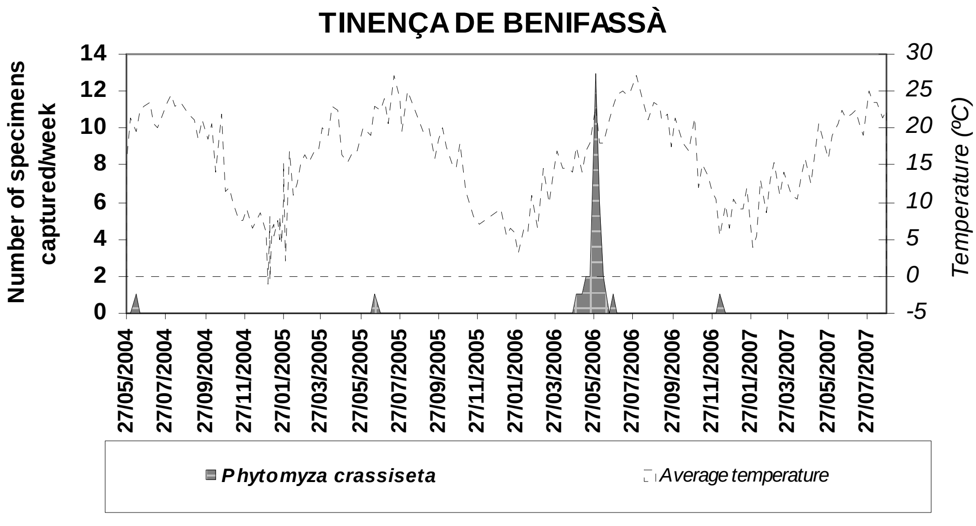


Figure 5-88. Space-time captures evolution of *Phytomyza crassiseta* Zetterstedt, 1860 males in Natural Park of “Tinença de Benifassà”.

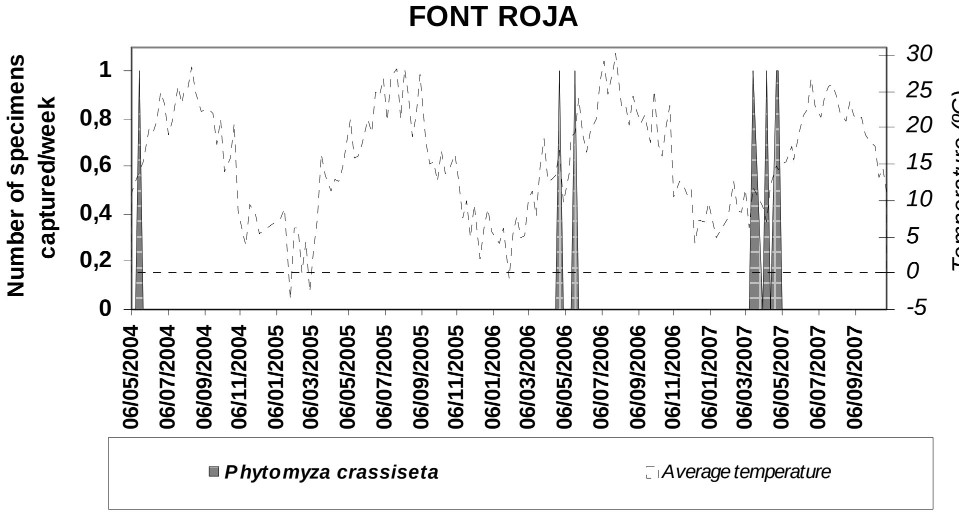


Figure 5-89. Space-time captures evolution of *Phytomyza crassiseta* Zetterstedt, 1860 males in Natural Park of "Font Roja".

Phenology: It is present in "Tinença de Benifassà" from the end of spring to mid-summer. Maximum captures registered were 13 males/week with 23ºC (30ºC max. and 16ºC min.) (Fig. 5-88). In "Font Roja" captures were carried out from mid-spring to the beginning of the summer. Captures were produced irregularly with maximums of 1 male/week. Optimum average temperature ranges registered for captures were 7.1-19.4ºC (23ºC max. and 5.6ºC min.) (Fig. 5-89).

Phytomyza gymnostoma Loew, 1858

= *Phytomyza algeciracensis* Strobl, 1906
= *Phytomyza palpalis* Hendel, 1936
= *Phytomyza palpata* Hendel, 1935 Preocc.
= *Agromyza phytomyzina* Hering, 1933

Material examined: Tinença de Benifassà: 1♂, 23-30.x.2006.

Diagnostic characters: Head with frons broad, 3 times width of eye, orbits conspicuously projecting above eye in profile; 2 *ors*, 3 *ori*, all on inner margin of the broad orbits; orbital setulae long, all proclinate; jowls deeply extended at rear, up to 2/3 height of eye; third antennal segment rounded at end but elongate; broad epistoma present, palps broadening distally; 3+1 strong *dc*, *acr* irregularly in 4 rows in front; wing length from 2.8 mm in male to 3.5 mm in female, second costal section long, 4 times length of fourth; second cross-vein lacking; colour: frons orange-yellow, hind-margin of eye and orbits to mid-*ori* black; third antennal segment black, first and second yellowish, palps black; mesonotum mat greyish black, sides of thorax uniformly dark; legs black, knees indistinctly yellowish.- Male genitalia: aedeagus as in SPENCER, 1976b: 337; postgonites greatly enlarged ventrally, with a strong, curved spine at end; surstyli free, extending far into epandrium, almost identical to those of *Phytomyza glabra* Hendel, 1935; 8th sternum rudimentary, present only as a very narrow strip loosely fused centrally to 8th tergum.

Distribution: Palaearctic: Austria, Czech Republic, Danish mainland, European Turkey, Finland, French mainland, Germany, Hungary, Italian mainland, Lithuania, Poland, Sicily, Slovakia, Slovenia, Spanish mainland, Sweden, The Netherlands, Ukraine, Yugoslavia; North Africa.

Host-plants: *Allium.*

This species was described mining on *Allium porrum* (L.). The larva feeds from the oviposition site in the leaf down into the root where it pupates. The large size (wing length up to 3.5 mm), the strongly projecting frons, and the atypical genitalia of *Phytomyza* suggest that this is a primitive species.

Phenology: It has been captured punctually at the end of October with average temperatures of 23.1ºC (28.9ºC max. and 17.3ºC min.).

Phytomyza plantaginis Robineau-Desvoidy, 1851

= *Phytomyza biseriata* Hering, 1937
= *Phytomyza genualis* Loew, 1869
= *Phytomyza nannodes* Hendel, 1935
= *Phytomyza plantaginicaulis* Hering, 1944
= *Phytomyza robinaldi* Goureau, 1851 Nomen oblitum.

Material examined: Tinença de Benifassà: 1♂, 1-8.vii.2004; 2♂, 23-30.v.2005; 2♂, 27.vi.2005-4.vii.2005; 1♂, 24.iv.2006-1.v.2006; 1♂, 8-15.v.2006; 4♂, 15-22.v.2006; 1♂, 22-29.v.2006; 1♂, 19-26.vi.2006; 2♂, 26.vi.2006-3.vii.2006; 1♂, 24.vii.2006-1.viii.2006; 2♂, 20-28.viii.2006; Lagunas de La Mata-Torrevieja: 1♂, 8-15.vi.2004; 1♂, 6-13.iii.2007; 1♂, 20-27.iii.2007; 2♂, 3-10.iv.2007; 3♂, 10-17.iv.2007; 1♂, 17-24.iv.2007; 7♂, 1-8.v.2007; 1♂, 8-16.v.2007.

Diagnostic characters: Agreeing closely with *Phytomyza crassiseta* Zetterstedt, 1860 with the important difference that the arista is slender, normal; the first and second antennal segments are also generally brighter yellow.- Male genitalia: aedeagus as in SPENCER, 1976b: 471.

Distribution: Palaearctic: Azores, Belarus, Britain I., Canary Is., Channel Is., Czech Republic, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Hungary, Ireland, Italian mainland, Latvia, Lithuania, Republic of Moldova, Norwegian mainland, Poland, Romania, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; Australian region; East Palaearctic; Near East; Nearctic region; Neotropical region; Oriental region.

Host-plants: *Plantago.*

Phytomyza plantaginis occurs commonly on *Plantago lanceolata* L. and *Plantago major* L. in Europe, but also on other species. This species have also been recorded as an introduction in the USA, Australia, and New Zealand. Males are known from Europe, and this species appear to be parthenogenetic in the areas where it has been introduced. The larva normally pupates in the leaf, but feeding may also take place in the stem.This last feeding habit was described in *Phytomyza plantaginicaulis* Hering (1944) (synonymy with *plantaginis* established by SPENCER, 1963).

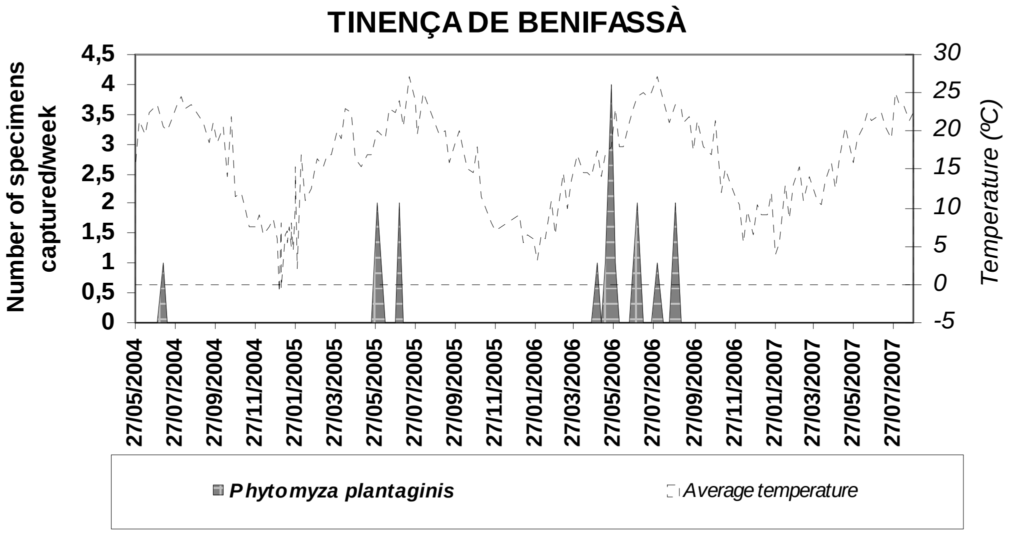


Figure 5-90. Space-time captures evolution of *Phytomyza plantaginis* Robineau-Desvoidy, 1851 males in Natural Park of "Tinença de Benifassà".

Phenology: It has been found in "Tinença de Benifassà" in spring and summer with a number of generations variably. In 2006, 5 generations were established. Maximum captures were undertaken in spring with 4 males/week when average temperatures were of 18ºC (23ºC max. and 13ºC min.) (Fig. 5-90). In "Lagunas de La Mata-Torrevieja" captures were produced in mid-spring with maximum captures of 7 males/week when average temperatures were of 21.5ºC (23.5ºC max. and 19.5ºC min.). 4 generations were registered in 2006, but captures are very irregular between years depending on climate (Fig. 5-91).

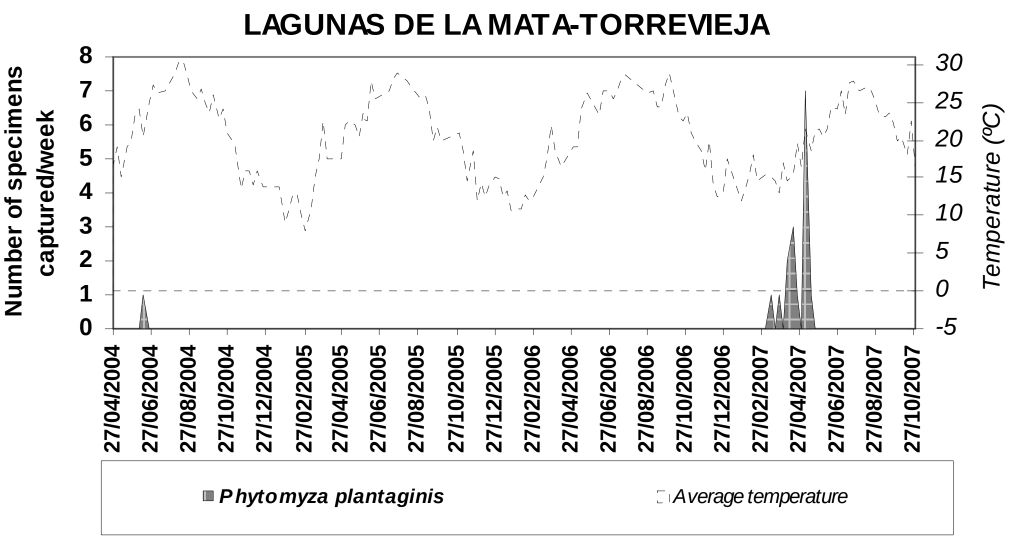


Figure 5-91. Space-time captures evolution of *Phytomyza plantaginis* Robineau-Desvoidy, 1851 males in Natural Park of "Lagunas de La Mata-Torrevieja".

Phytomyza ranunculi (Schrank, 1803)

= *Phytomyza albipes* Meigen, 1830
= *Phytomyza cinereovittata* Zetterstedt, 1848 As subsp. of *P. flava* Fallén, 1823
= *Phytomyza citrina* von Roser, 1840

= *Phytomyza flava* Fallén, 1823
= *Phytomyza flaveola* Fallén, 1810
= *Phytomyza flavoscutellata* Meigen, 1830
= *Phytomyza flavotibialis* Strobl, 1902
= *Phytomyza flavotibialis* Strobl, 1904 Preocc.
= *Phytomyza incisa* Macquart, 1835
= *Phytomyza islandica* Rydén, 1953 As subsp. of *P. ranunculi* (Schrank, 1803).
= *Phytomyza maculipes* Brullé, 1832
= *Phytomyza maculipes* Zetterstedt, 1848 Preocc.
= *Phytomyza pallida* Meigen ,1830
= *Phytomyza pentalinearis* Kuroda, 1954 As subsp. of *P. ranunculi* (Schrank, 1803).
= *Phytomyza praecox* Meigen, 1830
= *Phytomyza ranunculi* Kaltenbach, 1867 Preocc.
= *Phytomyza ranunculi* Robineau-Desvoidy, 1851 Preocc.
= *Phytomyza scutellata* Meigen, 1830
= *Phytomyza tenuipennis* Singh & Ipe, 1973
= *Phytomyza terminalis* Meigen, 1830
= *Phytomyza vitripennis* Meigen, 1830
= *Phytomyza zetterstedtii* Schiner, 1864

Material examined: <u>Tinença de Benifassà</u>: 1♂, 6-17.iv.2006; 1♂, 22-29.v.2006; 1♂, 23-30.x.2006; 1♂, 23-30.iv.2007; <u>Font Roja</u>: 1♂, 26.vi.2006-3.vii.2006.

Diagnostic characters: Sometimes 1 strong reclinate *ors* (upper) is present, greatly reduced; 1 incurved *ori*; third antennal segment round, more rarely slightly longer than broad; mesonotum with 3+1 very strong *dc*, *acr* sparse, irregularly in 2 rows; average wing length in male 2.6 mm (range 2.2-2.3), in male 2.8 (range 2.4-3.3), second costal section normally about 3.3 times length of fourth (range 2.6-4 times). The colour shows a remarkable seasonal variation. Specimens from overwintering puparia are conspicuously darker (var. *flavoscutellata*), in the summer and autumn generations the colour is essentially yellow. In all cases the third antennal segment is black, the first and second segments are yellow; in the dark form the hind-margin of the eye is black, the mesonotum is solidly black, the pleura largely so, and the scutellum is only narrowly yellow centrally; in the pale form the entire hind-margin of the eye is yellow, the dark area of the mesonotum can be only slightly differentiated, rusty-orange, or pale grey but invariably divided into bands and centrally yellow adjoining the scutellum; both pleura and scutellum are entirely yellow. A wide range of intermediate colour forms can occurs.- Male genitalia: aedeagus obviously divided basally, then fused throughout its length. The distal tubules in the rest position are more or less in a regular spiral. The length of the distiphallus can vary considerably, from 5 to 8 coils, coiling upwards (SPENCER, 1976b: 483).

Distribution: Palaearctic: Austria, Azores, Belarus, Belgium, Britain I., Canary Is., Channel Is., Czech Republic, Danish mainland, Estonia, European Turkey, Faroe Is., Finland, French mainland, Germany, Hungary, Iceland, Ireland, Italian mainland, Latvia, Lithuania, Madeira, Republic of Moldova, Norwegian mainland, Poland, Romania, Sardinia, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands; East Palaearctic; Near East; Nearctic region; North Africa; Oriental region.

Host-plants: *Ficaria, Myosorus, Ranunculus.*

The mining behaviour is forming an irregular linear mine on any part of the leaf. It is typical mining on *Ranunculus* in Europe.

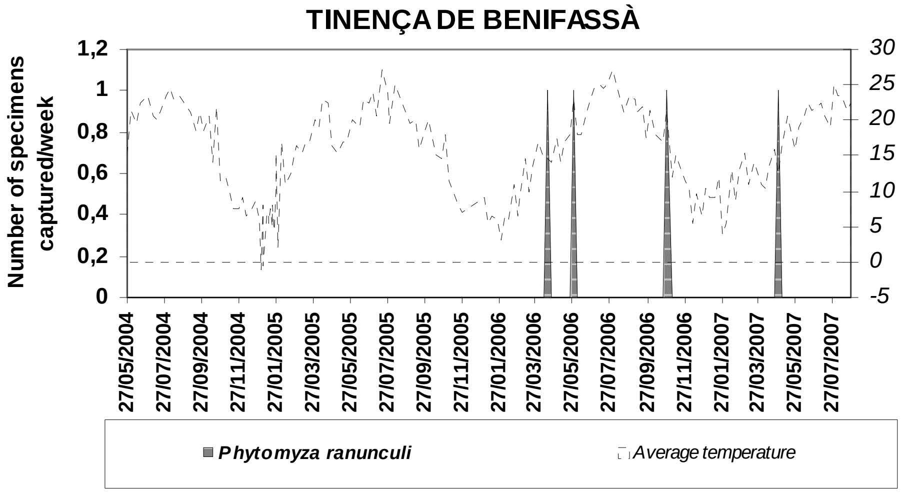


Figure 5-92. Space-time captures evolution of *Phytomyza ranunculi* (Schrank, 1803) males in Natural Park of "Tinença de Benifassà".

Phenology: It has been captured in spring and autumn in "Tinença de Benifassà", and in summer in "Font Roja". In both, maximum captures do not surpass 1 male/week. Average temperatures in times of captures oscillate between 14.5-23ºC (30ºC max. and 9ºC min.) in "Tinença de Benifassà" (Fig. 5-92), and 26.4ºC (34.4ºC max. and 18.3ºC min.) in "Font Roja".

Phytomyza rufipes Meigen, 1830

= *Phytomyza bistrigata* Strobl, 1906
= *Phytomyza brassicae* Hardy, 1853
= *Phytomyza femoralis* Brischke, 1871
= *Phytomyza genislatissimus* Strobl, 1893 As subsp. of *P. zetterstedtii* Schiner, 1864.
= *Phytomyza ruficornis* Zetterstedt, 1848
= *Phytomyza suphuripes* Meigen, 1830
= *sufuripes* auct. Misspelling.

Material examined: Tinença de Benifassà: 1♂, 6-17.iv.2006; 1♂, 24.iv.2006-1.v.2006; 1♂, 8-15.v.2006; 3♂, 2-12.x.2006; 8♂, 12-23.x.2006; 10♂, 23-30.x.2006; 8♂, 30.x.2006-6.xi.2006; 9♂, 6-13.xi.2006; 6♂, 13-20.xi.2006; 1♂, 20-27.xi.2006; 2♂, 27.xi.2006-4.xii.2006; 1♂, 1-8.i.2007; 1♂, 15-22.i.2007; 1♂, 5-12.ii.2007; 1♂, 12-19.ii.2007; 2♂, 19-26.ii.2007; 1♂, 5-12.iii.2007; 5♂, 12-20.iii.2007; 1♂, 20.iii.2007-2.iv.2007; 1♂, 2-9.iv.2007; Font Roja: 1♂, 1-11.xi.2004; Lagunas de La Mata-Torrevieja: 1♂, 21.xii.2004-18.i.2005; 1♂, 7-14.xi.2006; 2♂, 28.xi.2006-5.xii.2006; 1♂, 19-26.xii.2006; 3♂, 26.xii.2006-2.i.2007; 4♂, 2-24.i.2007; 1♂, 30.i.2007-6.ii.2007; 3♂, 13-20.ii.2007; 2♂, 20.ii.2007-6.iii.2007; 1♂, 6-13.iii.2007; 2♂, 13-20.iii.2007; 1♂, 10-17.iv.2007.

Diagnostic characters: Head with frons exceptionally broad, up to 3 times width of eye, conspicuously projecting above eye in profile, 2 equal *ors*, 2 or 3 *ori*; jowls unusually deeply extended at rear, up to ¾ height of eye; mesonotum with 3+1 strong *dc*, *acr* sparse, limited to a few hairs in front or entirely lacking; wing length from 2.5 mm in male to 3.5 mm in female; colour of frons yellowish or orange-brown; hind-margin of eye partially grey, *vte* usually just on dark ground, *vti* on yellow; third antennal segment varying from almost entirely black to largely yellow; mesonotum mat, ash-grey; humerus and notopleural area yellow; mesopleura yellow on upper margin but mat grey at least on lower three-quarters; legs: coxae yellow, femora largely yellow but with variable brownish striations; squamae and fringe pale.- Male genitalia: aedeagus as in SPENCER, 1976b: 491.

Distribution: Palaearctic: Britain I., Canary Is., Czech Republic, Danish mainland, Estonia, European Turkey, Finland, Germany, Iceland, Ireland, Italian mainland, Lithuania, Madeira, Norwegian mainland, Poland, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; Near East; Nearctic region; Neotropical region; North Africa.

Host-plants: *Alliaria, Brassica, Coringia, Diplotaxis, Sinapis, Moricandia, Peltaria, Raphanus, Rorippa, Sisymbrium.*

Phytomyza rufipes is a common pest of *Brassica* sp. in Europe, and has been recorded on eight further genera. The larva feeds initially in the petiole or stem, and with its large size and internal feeding is almost certainly a primitive species.

Phenology: It is a common species in the Natural Parks studied. In “Tinença de Benifassà” this species is practically present in all seasons; in “Font Roja” it has been found punctually in autumn; while in “Lagunas de La Mata-Torrevieja” it is present when moderate temperatures are recorded in winter and spring. “Tinença de Benifassà” registered generations in spring and in autumn in 2006. Maximum captures were produced in October with 10 males/week when the average temperature range was 21.5ºC (28ºC max. and 15ºC min.) (Fig. 5-93). In “Lagunas de La Mata-Torrevieja” captures were produced from the end of October to the end of April. Maximum captures were 4 males/week with average temperatures of 12ºC (15ºC max. and 9ºC min.) (Fig. 5-94).

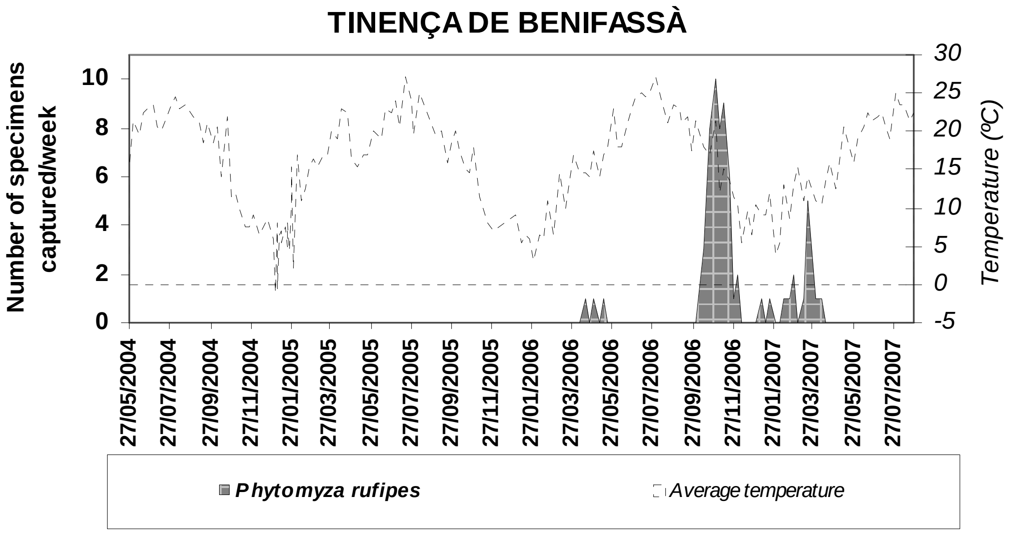


Figure 5-93. Space-time captures evolution of *Phytomyza rufipes* Meigen, 1830 males in Natural Park of “Tinença de Benifassà”.

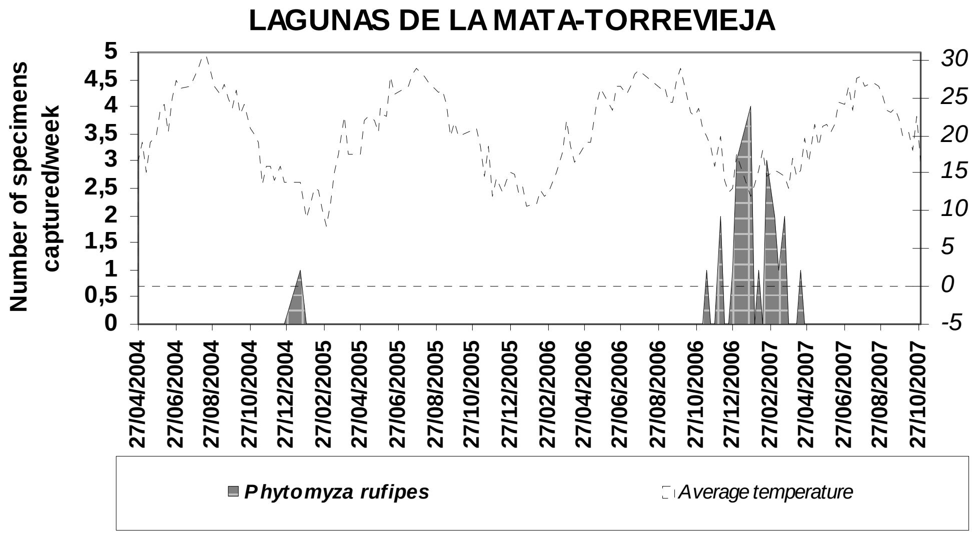


Figure 5-94. Space-time captures evolution of *Phytomyza rufipes* Meigen, 1830 males in Natural Park of "Lagunas de La Mata-Torrevieja".

Phytomyza sedi Kaltenbach, 1869

= *Phytomyza catalaunica* Spencer, 1960

Material examined: Lagunas de La Mata-Torrevieja: 2♂, 3-10.iv.2007.

Diagnostic characters: KALTENBACH, 1869: 172.

Distribution: Palaearctic: French mainland, Germany, Spanish mainland, Yugoslavia.

Host-plants: *Sedum.*

Phytomyza sedi and *Phytomyza rhodiolae* Griffiths, 1976 are probably sister-species and form a monophyletic group with *Phytomyza sedicola* Hering, 1924. *P. sedi* is an European species, while *P. rhodiolae* is only known in Yukon Territory (Canada).

Phenology: Captures were produced in spring in "Lagunas de La Mata-Torrevieja" with an average temperature of 14.5ºC (17ºC max. and 12ºC min).

Phytomyza tanaceti Hendel, 1923

= *Phytomyza klimeschi* Hering, 1943

Material examined: Tinença de Benifassà: 1♂, 12-23.x.2006.

Diagnostic characters: Agreeing closely with *Phytomyza ptarmicae* Hering, 1937, and also with *Phytomyza bipunctata* Loew, 1858 with the following points of difference: second antennal segment normally black, yellow patches and hind-corners of mesonotum small, indistinct, not extending to inner post-alar.- Male genitalia: aedeagus as in SPENCER, 1976b: 513, with basal sclerites without spinules; ventral lobe long, particularly below the short lateral side-pieces; equal esclerites arising from distal ends of the two basal sclerites, with a small spot of chitinization beyond their end; paired distal sclerites short.

Distribution: Palaearctic: Austria, Britain I., Czech Republic, Danish mainland, Estonia, Finland, French mainland, Germany, Ireland, Lithuania, Norwegian mainland, Poland, Slovakia, Sweden; East Palaearctic.

Host-plants: *Achillea, Tanacetum.*

Phytomyza tanaceti is widespread in Europe, and is closely resembles to *P. ptarmicae* but with distinctive differences in male genitalia.

Phenology: Captures were produced punctually in mid October in “Tinença de Benifassà” with an average temperatures of 17ºC (23ºC max. and 12ºC min.).

5.3.2.12 Genus ***Pseudonapomyza*** Hendel, 1920

Pseudonapomyza genus is composed of 44 species in the Palaearctic region. MARTINEZ (2004) cites the presence of 19 species in Europe and 7 in Spain. Later, CERNY (2004) updates this number to 8 species including *Pseudonapomyza europaea* Spencer, 1973. In this thesis are reported *Pseudonapomyza atratula* Zlobin, 2002 and *Pseudonapomyza palliditarsis* Cerny, 1992 new for Spain and 5 new species for science described. So that, the number of *Pseudonapomyza* species reach the figure of 15 species in the continental Spain.

This genus at present include two distinct groups: one feeding on Gramineae, having the third antennal segment angulate and distinctive wing venation, and the other occurring in the Old World tropics feeding on Acanthaceae (SPENCER, 1972b). Known host-plant families mined by *Pseudonapomyza* in the world are listed by BENAVENT-CORAI *et al.* (2005a) including Acanthaceae, Amaranthaceae, Compositae and Gramineae.

Key diagnostic characters: orbits normal, separated throughout by the frons; orbital setulae erect, reclinate or absent; costa ending only to R_{4+5}; third antennal segment angulate.

In the 6.4 chapter of this thesis "Modelling climate effects on the ecological dynamics of *Pseudonapomyza* (Diptera: Agromyzidae) genus" the behaviour of *Pseudonapomyza* genus has been developed extensively based on weather conditions, also indicating the phenological evolution.

Pseudonapomyza atra (Meigen, 1830)

= *Phytomyza acuticornis* Loew, 1858
= *Napomyza hindustanica* Garg, 1971
= *Phytomyza morio* Zetterstedt, 1848
= *Phytomyza nitidula* Malloch, 1913
= *Pseudonapomyza stanionyteae* Pakalniškis, 1992

Material examined: Tinença de Benifassà: 1♂, 22-29.vii.2004; 1♂, 16-23.v.2005; 8♂, 23-30.v.2005; 8♂, 6-13.vi.2005; 6♂, 13-20.vi.2005; 2♂, 27.vi.2005-4.vii.2005; 2♂, 4-

11.vii.2005; 2♂, 11-18.vii.2005; 3♂, 8.viii.2005-3.ix.2005; 1♂, 6-17.iv.2006; 1♂, 24.iv.2006-1.v.2006; 1♂, 8-15.v.2006; 3♂, 15-22.v.2006; 20♂, 22-29.v.2006; 9♂, 29.v.2006-5.vi.2006; 8♂, 5-12.vi.2006; 2♂, 19-26.vi.2006; 2♂, 26.vi.2006-3.vii.2006; 4♂, 3-10.vii.2006; 1♂, 20-28.viii.2006.

Diagnostic characters: Frons little wider than eye, conspicuously projecting above eye, increasingly so towards antennae; up to 5 orbital bristles, orbital setulae reclinate; third antennal segment angulate; mesonotum deep black, largely mat but more shining from rear, with 3 strong post-sutural *dc*; *acr* irregularly in 5-6 rows; wing: length from 1.3 to 2.1 mm, second costal section short, generally about 1 ½ times length of fourth; legs entirely black, squamae and fringe white.- Male genitalia: aedeagus as in SPENCER, 1976b: 327.

Distribution: Palaearctic: Austria, Azores, Belarus, Belgium, Britain I., Bulgaria, Canary Is., Czech Republic, Danish mainland, Estonia, European Turkey, French mainland, Germany, Hungary, Italian mainland, Latvia, Lithuania, Madeira, Poland, Romania, Slovakia, Spanish mainland, Sweden, The Netherlands, Ukraine, Yugoslavia; Nearctic region, North Africa, Oriental region.

Host-plants: *Apera, Avena, Holcus, Hordeum, Lolium, Phalaris, Poa, Secale, Triticum.*

It has been found to be mining on eight genera in the Aveneae and Triticieae. It is widespread in Europe and also present in USA. The puparium present typical spinules as many species in this group.

Phenology: It is present in "Tinença de Benifassà" at the end of spring and summer. Phenologycal behaviour shows 3-5 generations. Maximum captures registered were 20 males/week with average temperatures of 23ºC (30ºC max. and 16ºC min.) (Fig. 5-95).

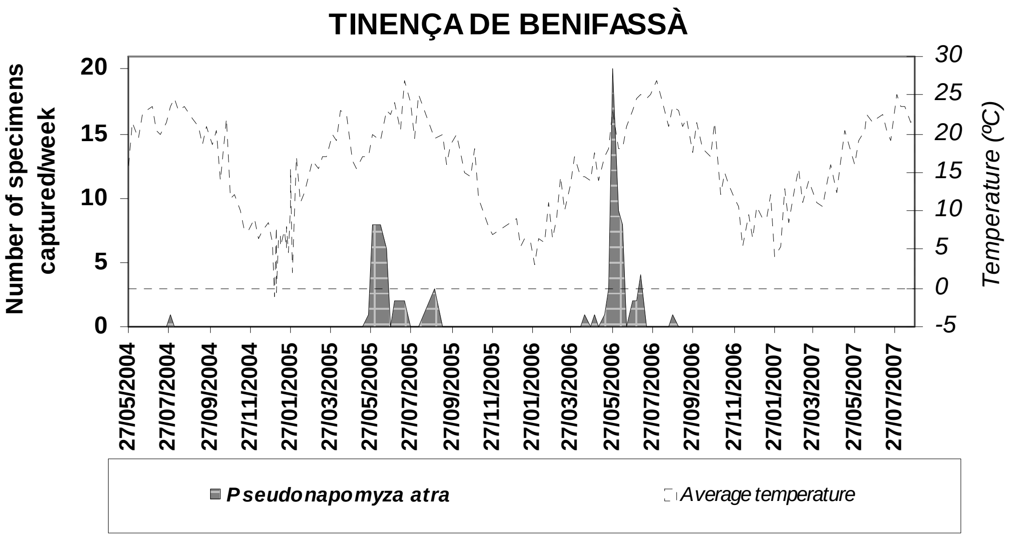


Figure 5-95. Space-time captures evolution of *Pseudonapomyza atra* (Meigen, 1830) males in Natural Park of "Tinença de Benifassà".

Pseudonapomyza hispanica Spencer, 1973

Material examined: Tinença de Benifassà: 2♂, 15-22.v.2006.

Diagnostic characters. Head. (Fig. 5-96a). Frons slightly prominent only at level of lunule. 3rd antennal segment pointed, as long as wide, minutely pubescent with short brown pilosity uniformly distributed. Arista normal, with very fine, and very short pilosity, these clearly more distinct at the border of the antenna. Fronto-orbital plate (= parafrontalia) with 2 *ors* (upper orbital) and 2 curved inwards *ori* (lower orbital). Normally, 1 *ors* (lower) inwards directed with a inclination of 45º to the upper part of the head and 1 *ors* (upper) upwards directed in line the head are present. Lower *ori* shorter than upper. Orbital setulae short (minimum 10) slightly reclinated along *ori* and clearly reclinated along *ors* in an only row. Ocellar triangle as long as wide (0.1 x 0.1 mm), extends to level of *ors*. Two ocellar bristles (*oc*) slightly divergent or parallel, slightly smaller and as strong as *ors*. Two postocellar bristles (*poc*) clearly divergent and equal or slightly longer than *oc*. Internal bristle (*vti*) (= inner vertical setae [*i vt s*] long and strong, much longer than *ors* and *ori*. External vertical bristle (*vte*) (= outer vertical setae [*o vt s*]) strong but a little smaller than *vti* (on average, *vti* 1.5 times longer than *ors*). Inter-ocular space measured (in frontal view) at level of *ors* = 2.25 X eye (in profile, at a highest measurement). Cheeks forms *arc* below eye. Gena including cheeks (at highest measurement) = 0.45 X eyes (in profile at highest measurement). Eyes without pilosity.

Thorax. Mesonotum with 3 long and strong dorsocentral bristles (*dc*) increasing in size to scutellum. *acr* numerous (10-12) irregularly arranged in 8 no spaced rows. Intra alar seta (*ia*) small, about same size as *acr*. Anterior and posterior supra alar setae (*spal*) as long and strong as first and second *dc*. Humeral cali with 1 anterior bristle accompanied by 4-5 small setulae. Notopleura with 2 normal notopleural bristles. Posterior part of anapisternum (mesopleura) with 1 strong bristle, and generally 1 small setula at each side. katapisternum (sternopleura) with 1 strong bristle situated at supero-posterior angle. Disc of scutellum without particular seta except usual 4. 2 apical scutellar setae (*ap sctl s*) generally parallel or very slightly convergent; 2 basal scutellar setae (*b sctl s*) about same size as *ap sctl s*, slightly directed outwards. Wing: length (on average) 1.3 x 0.6 (long x wide) mm. Thickening of costal (*C*) vein, clearly reaching R_{4+5} ending much before wing tip. Second and third costal section short. In proportion the length from first to fourth costal section is approximately 1:1:0.5:1. Discal cell (*dm*) and transverse (*dm-cu*) [second cross-vein] missing. Legs: with normal pilosity with the usual pre-apical bristle.

Abdomen. Setae of the tergites very distinct and relatively numerous across all abdomen.

Coloration. Head entirely brownish, face, front and orbital stripes brown. Lunule light brown. Inner vertical setae (*i vt s* = *vti*) and outer vertical setae (*o vt s* = *vte*) on brown ground. Ocellar triangle dark brown like cheeks. Gena light brown. Torax and scutellum uniformly brown. Mesopleural and sternopleural fringe light brown close to wing. Halter white-transparent. Legs entirely brown. Abdomen brown on the upper side and light brown on the bottom side. Tergites 1 to 5 with a clear darker brown band between contiguous margin, with wide bottom brownish spots.

Aedeagus and associated structures. Aedeagus (Figs. 5-96b and 5-96c). Cercus short and thin. Surstylus (=gonostylus) with uniform pilosity (12-15 little bristles) inside of each lower corner (Fig. 1d). Sperm pump (=ejaculatory apodeme) longer (0.22 mm) than wide (0.18 mm) (wider part) expanded uniformly on the two sides (Fig. 5-96e).

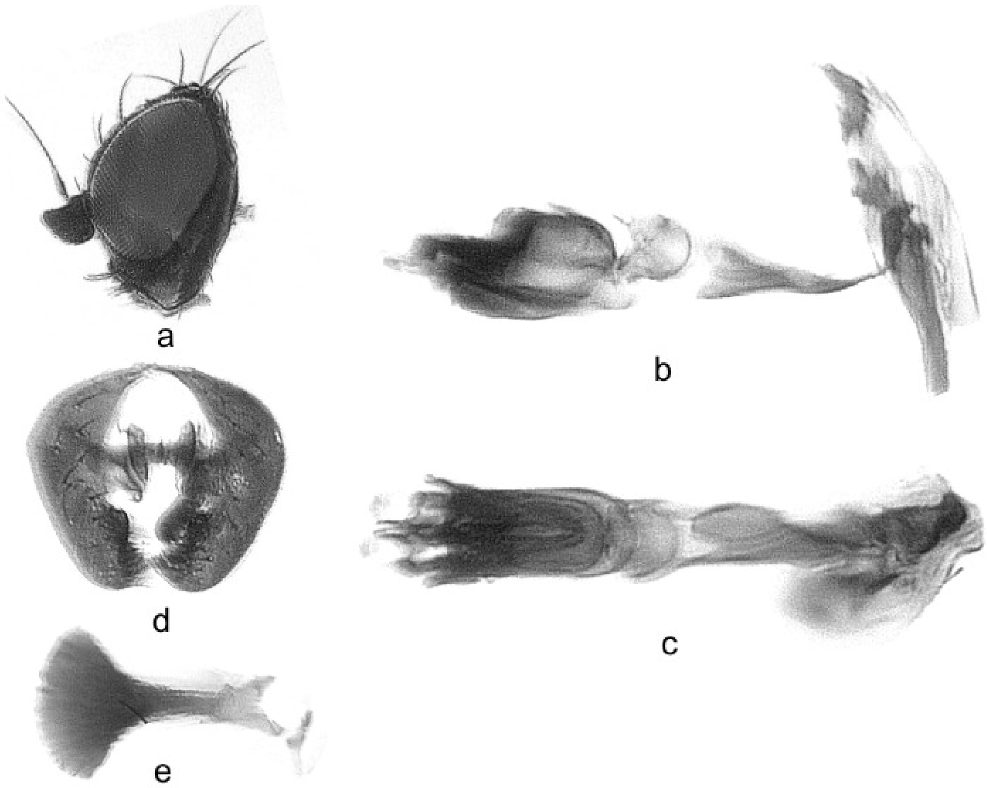


Figure 5-96. *Pseudonapomyza hispanica.* a- Head in lateral view; b- aedeagus in lateral view; c- aedeagus in ventral view. d- epandrium in anterior view; e- Sperm pump in lateral view. (Design by R. GIL-ORTIZ).

Distribution: Palaearctic: European Turkey, Spanish mainland; Near East.

Host-plants: *Sorghum*.

Pseudonapomyza hispanica has been cited mining *Sorghum* in Israel (SPENCER, 1990). It is considered a pest into Agromyzidae family (BENAVENT-CORAI *et al.*, 2004)

Phenology: This species was captured when average temperature was 18ºC (13ºC min. and 23ºC max.). Based on the captures an only generation in spring is observed, making the evolution of this species difficult to predict. Although it is also most probably present in summer and autumn.

Pseudonapomyza spinosa Spencer 1973

Material examined: Tinença de Benifassà: 1♂, 29.vii.2004-5.viii.2004; 1♂, 12-19.viii.2004; 1♂, 27.vi.2004-4.vii.2004; 1♂, 18-28.vii.2005; 1♂, 28.vii.2005-1.viii.2005; 1♂, 1-8.viii.2005; 1♂, 8.viii.2005-2.ix.2005; 1♂, 15-22.v.2006; 1♂, 5-

12.vi.2006; 1♂, 3-10.vii.2006; 1♂, 10-17.vii.2006; 1♂, 24.vii.2006-1.viii.2006; 1♂, 1-10.viii.2006; 1♂, 20-28.viii.2006; 1♂, 28.viii.2006-6.ix.2006; Font Roja: 1♂, 29.vii.2004-2.viii.2004; 1♂, 9-16.viii.2004; 1♂, 31.vii.2006-7.viii.2006; 2♂, 7-14.viii.2006; 1♂, 21-28.viii.2006; 3♂, 28.viii.2006-4.ix.2006; Lagunas de La Mata-Torrevieja: 2♂, 10-17.viii.2004; 1♂, 5-12.x.2004; 1♂, 2-9.xi.2004; 3♂, 9-16.xi.2004; 2♂, 30.viii.2005-6.ix.2005; 5♂, 6-13.ix.2005; 7♂, 20-27.ix.2005; 1♂, 27.ix.2005-4.x.2005; 2♂, 15-22.xi.2005; 1♂, 29.xi.2005-6.xii.2005; 1♂, 19-26.ix.2006; 2♂, 26.ix.2006-3.x.2006; 7♂, 17-24.x.2006; 1♂, 24-31.x.2006; 2♂, 31.x.2006-7.xi.2006; 1♂, 28.xi.2006-5.xii.2006.

Diagnostic characters: Adult with third antennal segment with fine point at upper corner; distance between first and second dc substantially greater than between second and third, third small, less than half length of second; wing length from 1.3-1.6 mm, second costal section little longer than fourth. Frons colour distinctly brown, ocellar triangle brilliantly shining black, orbits only weakly shining; mesonotum shining black but appearing slightly grey-dusted viewed from front; squamae and fringe silvery-white. Male genitalia.- Distiphallus large, conspicuously black, appearing largely entire as in SPENCER, 1973: 275.

Distribution: Palaearctic: Canary Is., European Turkey, Spanish mainland; Afrotropical region; Australian region; Near East; North Africa; Oriental region.

Host-plants: *Brachiaria, Eleusine, Hordeum, Triticum.*

The host range is in part overlapping with *Pseudonapomyza spicata* (Malloch, 1914), but the male genitalia is really distinctly different from *Ps. spicata*.

Phenology: It is present in the three Natural Parks studied in summer, but in the “Tinença de Benifassà” and “Lagunas de La Mata-Torrevieja” it has also been found in autumn. In “Tinença de Benifassà” captures do not exceed 1 males/week, the normal average temperatures of captures comprised between 20-25ºC (32ºC max. and 11ºC min.) (Fig. 5-97).

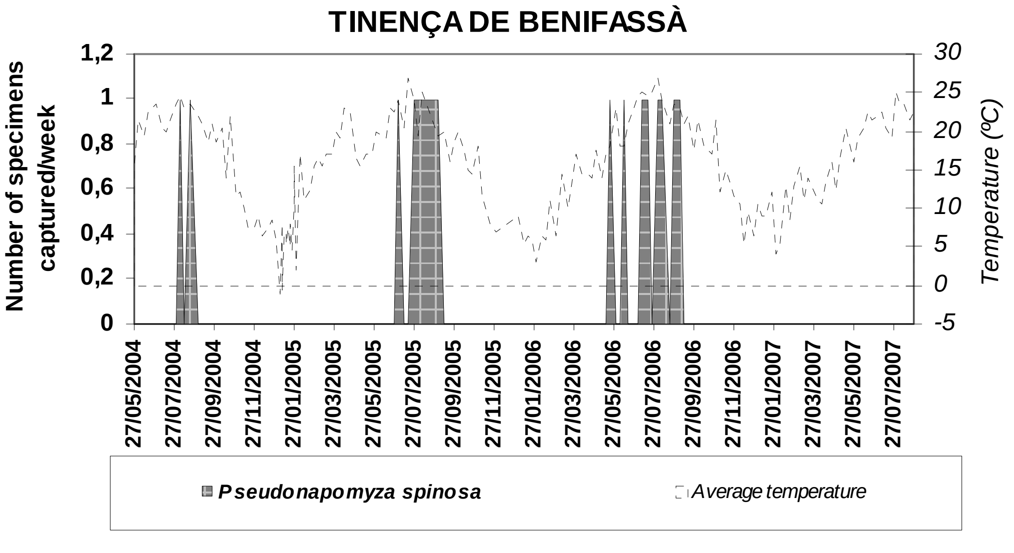


Figure 5-97. Space-time captures evolution of *Pseudonapomyza spinosa* Spencer, 1973 males in Natural Park of “Tinença de Benifassà”.

In “Font Roja” captures were very poor registering punctually a maximum of 3 males/week with average temperatures of 22.2ºC (29ºC max. and 15.1ºC min.) (Fig. 5-98).

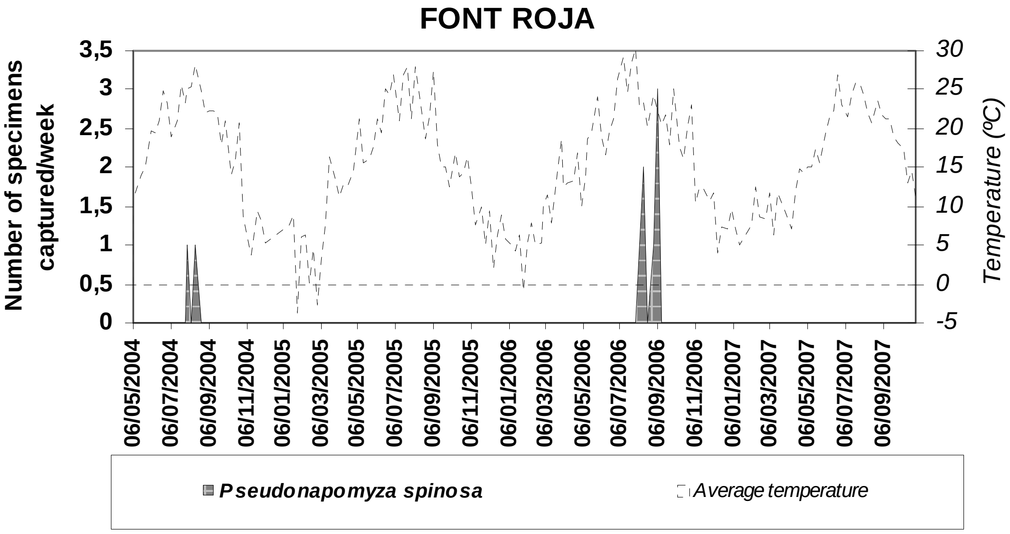


Figure 5-98. Space-time captures evolution of *Pseudonapomyza spinosa* Spencer, 1973 males in Natural Park of “Font Roja”.

In “Lagunas de La Mata-Torrevieja”, 3-4 generations comprised from end summer till to the beginning of winter have been registered. Maximum captures were 7 males/week in autumn with average temperatures between 21.8-22.5ºC (27ºC max. and 18ºC min.) (Fig. 5-99).

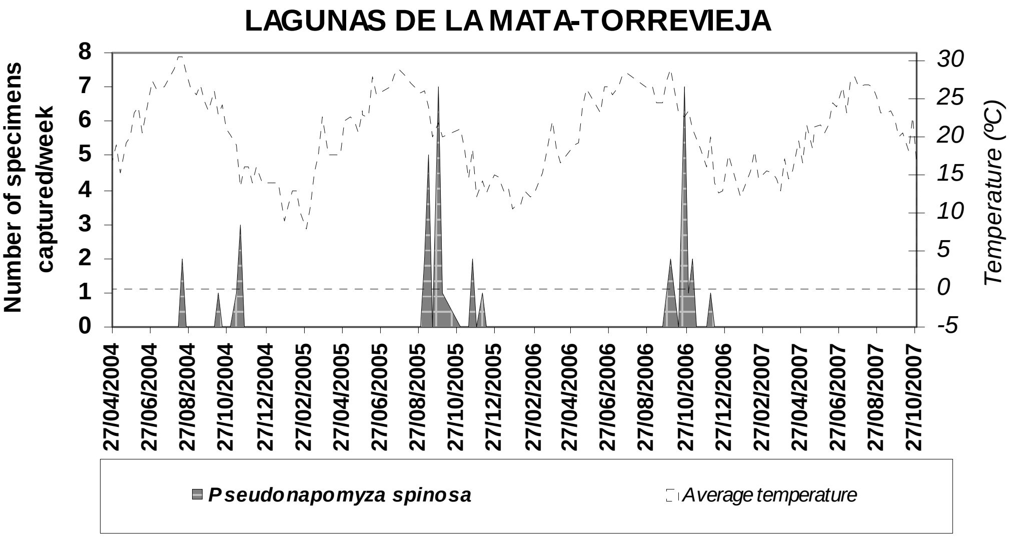


Figure 5-99. Space-time captures evolution of *Pseudonapomyza spinosa* Spencer, 1973 males in Natural Park of “Lagunas de La Mata-Torrevieja”.

Pseudonapomyza strobliana Spencer, 1973

Material examined: Tinença de Benifassà: 1♂, 27.vi.2005-4.vii.2005 and 1♂, 1-8.viii.2005.

Diagnostic characters. **Head**. (Fig. 5-100a). Frons slightly prominent at level of lunule. 3rd antennal segment strongly pointed, as long as wide, minutely pubescent with short brown pilosity, these clearly more distinct in the body of the antenna. Arista normal, with very fine, and very short pilosity. Fronto-orbital plate (= parafrontalia) with 2 *ors* (upper orbital) and 2-3 *ori* (lower orbital). Normally, 1 *ors* (lower) inwards directed with a inclination of 45º to the upper part of the head and 1 *ors* (upper) upwards directed slightly inclined to the exterior part of the head are present. Orbital setulae short erected along *ori* and reclinated along *ors* in an only row. Ocellar triangle as longer as wide (0.1 x 0.1 mm), extends to level of *ors*. Two ocellar bristles (*oc*) slightly divergent or parallel, slightly smaller and as strong as *ors*. Two postocellar bristles (*poc*) slightly divergent and equal or slightly longer than *oc*. Internal bristle (*vti*) (= inner vertical setae [*i vt s*] long and strong, much longer than *ors* and *ori*. External vertical bristle (*vte*) (= outer vertical setae [*o vt s*]) strong but much smaller than *vti* (on average, vti 1.5 times longer than *ors*). Inter-ocular space measured (in frontal view) at level of *ors* = 1.3 X eye (in profile, at a highest measurement). Cheeks forms *arc* below eye. Genae including cheeks (at highest measurement) = 0.43 X eyes (in profile at highest measurement). Eyes without pilosity.

Thorax. Mesonotum with 3 long and strong dorsocentral bristles (*dc*) incresing in size to scutellum. *acr* numerous (minimum 12) irregularly arranged in 8 relatively spaced rows. Intra alar seta (*ia*) small, about same size as *acr*. Anterior and posterior supra alar setae (*spal*) as long and strong as first and second *dc*. Humeral cali with 1 anterior bristle accompanied by 4-5 small setulae. Notopleura with 2 normal notopleural bristles. Posterior part of anapisternum (mesopleura) with 1 strong bristle, and generally 1 small setula at each side. Katapisternum (sternopleura) with 1 strong bristle situated at supero-posterior angle. Disc of scutellum without particular setula except usual 4. 2 apical scutellar setulae (*ap sctl s*) generally parallel or very slightly convergent; 2 basal scutellar setulae (*b sctl s*) about same size as *ap sctl s*, directed slightly inwards. Wing: length (on average) 1.3 x 0.6 (long x wide) mm. Thickening of costal (*C*) vein, clearly reaching R_{4+5} ending much before wing tip. Second and third costal section short. In proportion the length from first to fourth costal section is approximately 1:0.9:0.4:1. Discal cell (*dm*) and transverse (*dm-cu*) [second cross-vein] missing. Legs: with normal pilosity with the usual pre-apical bristle.

Abdomen. Setae of the tergites very distinct and relatively numerous arranged on dorsal part, while on ventral side fine pilosity is present.

Coloration. Head entirely brownish, face, front and orbital stripes brown. Lunule dark brown. Inner vertical setae (*i vt s = vti*) and outer vertical setae (*o vt s = vte*) on brown ground. Ocellar triangle dark brown like cheeks. Gena light brown. Torax and scutellum uniformly brown. Mesopleural and sternopleural fringe light brown close to wing. Halter white-transparent. Legs entirely brown. Abdomen brown on the upper side and light brown on the bottom side. Tergites 1 to 5 with a clear darker brown band between contiguous margin, with wide bottom brownish spots.

Aedeagus and associated structures. Aedeagus (Figs. 5-100a and 5-100b). Cercus short and thin. Surstylus (=gonostylus) with dense pilosity inside of each lower corner (Figs. 5-100d and 5-100e). Sperm pump (=ejaculatory apodeme) longer (0.25 mm) than wide (0.15 mm) (wider part) expanded uniformly on the two sides.

Distribution: Czech Republic, French mainland, Germany, Hungary, Poland, Spanish mainland, Ukraine, Yugoslavia.

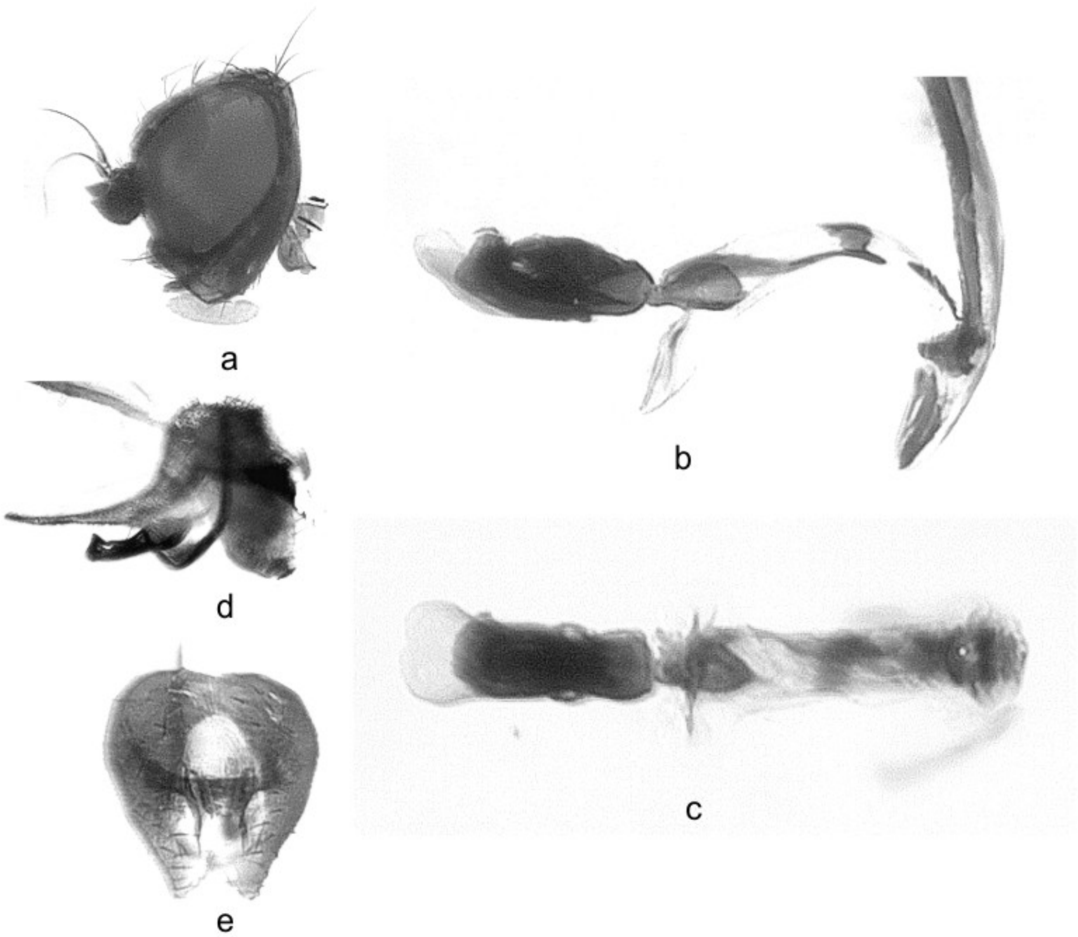


Figure 5-100. *Pseudonapomyza strobliana*. a- Head in lateral view; b- aedeagus in lateral view; c- aedeagus in ventral view; d- epandrium lateral view; e- epandrium in anterior view. (Design by R. GIL-ORTIZ).

Host-plants: Unknown.

Phenology: This species was captured when the average temperature ranges 24-25ºC (17ºC min. and 32ºC max.). Based on the captures at least two generations are observed in summer, being probably composed by several generations beginning in the spring and ending in the late autumn.

Pseudonapomyza vota Spencer, 1973

Material examined: Tinença de Benifassà: 1♂, 4-11.xi.2004; 6♂, 6-13.vi.2005; 2♂, 27.vi.2005-4.vii.2005; 1♂, 18-28.vii.2005; 1♂, 28.vii.2005-1.viii.2005; 1♂, 1-

8.viii.2005; 3♂, 8.viii.2005-2.ix.2005; 1♂, 22-29.v.2006; 2♂, 19-26.vi.2006; 1♂, 10-17.vii.2006; 1♂, 17-24.vii.2006; 3♂, 24.vii.2006-1.viii.2006; 2♂, 1-10.viii.2006; 2♂, 20-28.viii.2006; 3♂, 6-11.ix.2006; Lagunas de La Mata-Torrevieja: 1♂, 17-24.v.2005; 1♂, 27.ix.2005-4.x.2005.

Diagnostic characters: Small species; wing length in male 1.4 mm, with second costal section short, equal to length of fourth; frons narrow, equal to width of eye; third antennal segment conspicuously angulate; frons colour brownish-black, orbits distinctly shining; mesonotum shining black; wings hyaline, veins dark, almost black, squamae and fringe silvery-white. Male genitalia as in SPENCER, 1973: 278.

Distribution: Palaearctic: French mainland, Spanish mainland.

Host-plants: Unknown.

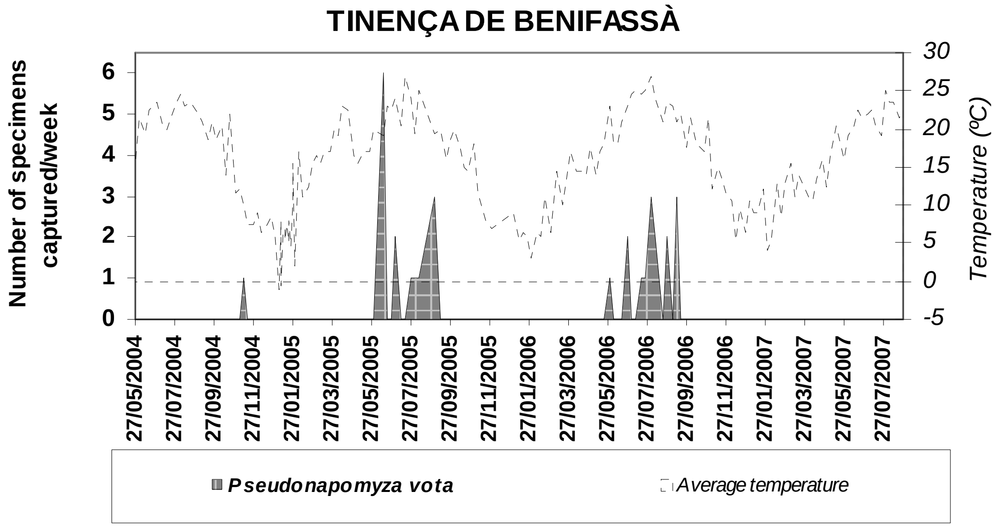


Figure 5-101. Space-time captures evolution of *Pseudonapomyza vota* Spencer, 1973 males in Natural Park of "Tinença de Benifassà".

Phenology:. In "Tinença de Benifassà" shows 3-5 generations distributed from the summer to the beginning of the autumn. Maximum captures were of 6 males/week with average temperature of 19ºC (23ºC max. and 15ºC min.) (Fig. 5-101). In "Lagunas de La Mata-Torrevieja" little captures were produced from the late spring to the beginning of the autumn with average temperature of 20.5-21.8ºC (24ºC max. and 16ºC min).

5.3.2.13 Genus *Ptochomyza* Hering, 1942

Ptochomyza is a little genus composed of 4 species in the Palaearctic region, and also present in Europe. In Spain, only two species are cited *Pseudonapomyza asparagi* Hering, 1942 and *Ptochomyza asparagivora* Spencer, 1964 (MARTINEZ, 2004).

Ptochomyza asparagi Hering, 1942 is only known to cause damage on *Asparagus* in Central Europe. The closely related species *Ptochomyza asparagivora* feeds on wild and cultivated *Asparagus* species in the Mediterranean and Afrotropical regions (DEMPEWOLF, 2005).

Key diagnostic characters: Adult size is generally small, second costal section of wing is unusually short, the cross veins are reduced as in *Phytomyza*; one of the two notopleural bristles are sometimes missing; frontorbits are strongly projecting; the orbital setae are quite large relative to the frontorbital bristles and are partly upright and proclinate; dorsocentral bristles are not much longer than acrostichals, often not recognizable.

Host-plants families mined by *Ptochomyza* are Asparagaceae, Ranunculaceae and Umbelliferae (BENAVENT-CORAI *et al.*, 2005a).

Ptochomyza asparagi Hering, 1942

Material examined: Tinença de Benifassà: 2♂, 20-27.v.2004; 10♂, 27.v.2004-3.vi.2004; 4♂, 3-10.vi.2004; 5♂, 10-17.vi.2004; 1♂, 25.vi.2004-1.vii.2004; 1♂, 16-23.v.2005; Font Roja: 3♂, 20-27.v.2004; 1♂, 17-24.vi.2004; 1♂, 30.iii.2006-6.iv.2006; Lagunas de La Mata-Torrevieja: 1♂, 6-13.iii.2007; 1♂, 6-13.iii.2007; 1♂, 20-27.iii.2007; 1♂, 10-17.iv.2007; 1♂, 1-8.v.2007.

Diagnostic characters: Minute yellow species, wing length little more than 1 mm; frons conspicuously projecting above eye towards base of antennae; orbital bristles short, 1 *ors*, 4 or *5 ori*, orbital setulae minute, proclinate; jowls deeply extended at rear, 2/3 height of eye, eye slanting; third antennal segment small, round, arista short; mesonotum up to 8 *dc*, becoming very short towards suture, no stronger than acrostichals, these sparse in 2 rows; wing length from slightly less than 1 mm in male to 1.3 mm in largest females, veins R_{2+3} and R_{4+5} curving, second costal section unusually short, only slightly longer than fourth; frons colour with entire hind-margin of eye yellow, third antennal segment somewhat darker, orange-brown to greyish; mesonotum mat greyish-black but broadly yellow centrally adjoining scutellum, the dark areas normally divided into 3 distinct bands; scutellum largely yellow, with small dark patches laterally; mesopleura entirely yellow; legs: coxae and femora bright yellow, tibiae and tarsi more brownish; squamae yellow, with dark margin and fringe. Male genitalia.- Aedeagus as in SPENCER, 1973: 170, a simplified structure ending in a single slender tubule.

Distribution: Palaearctic: French mainland, Germany, Hungary, Lithuania, Spanish mainland; East Palaearctic.

Host-plant: *Asparagus.*

Ptochomyza asparagi is only known on *Asparagus officinalis* L. where the larvae feeds on the fine leaves and more rarely in the stem, pupating internally. The head orbits projecting strongly and the wing venation with the second costal section unusually short characteristic of the genus. The genitalia are greatly simplified.

Phenology: It is basically present in spring and summer in all three Natural Parks studied. Captures were very low globally. Maximums of 10 males/week were registered in "Tinença de Benifassà" with average temperatures of 21.5ºC (28ºC max. and 15ºC min.) (Fig. 5-102). In "Font Roja" and "Lagunas de la Mata-Torrevieja", average temperatures of captures were 15.2ºC (21.5ºC max. and 8.9ºC min.) and 13-21.5ºC (23.5ºC max. and 10.5ºC min.), respectively (Figs. 5-103 and 5-104).

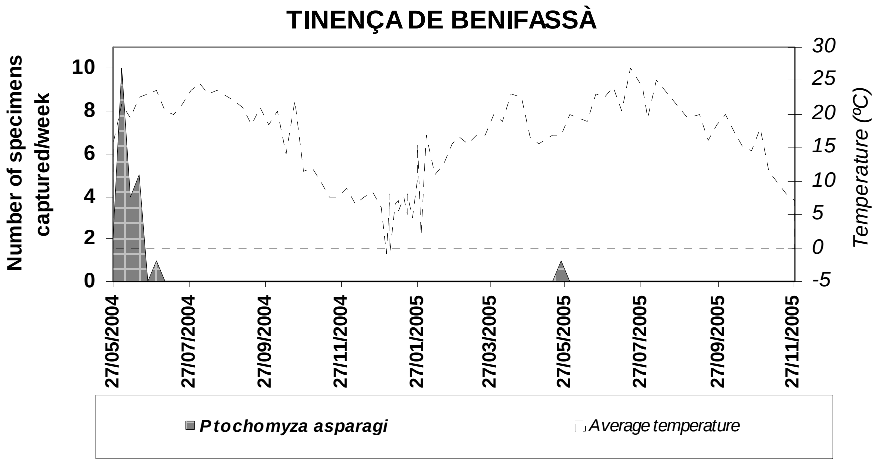


Figure 5-102.- Space-time captures evolution of *Ptochomyza asparagi* Hering, 1942 males in Natural Park of "Tinença de Benifassà".

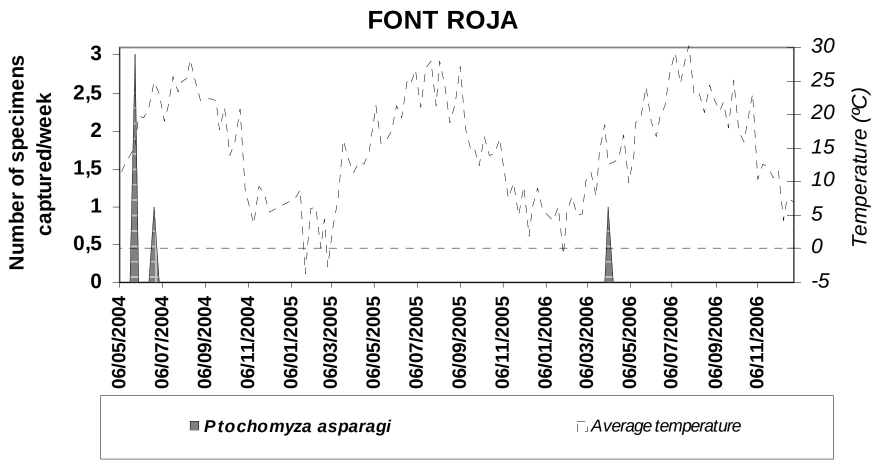


Figure 5-103. Space-time captures evolution of *Ptochomyza asparagi* Hering, 1942 males in Natural Park of "Font Roja".

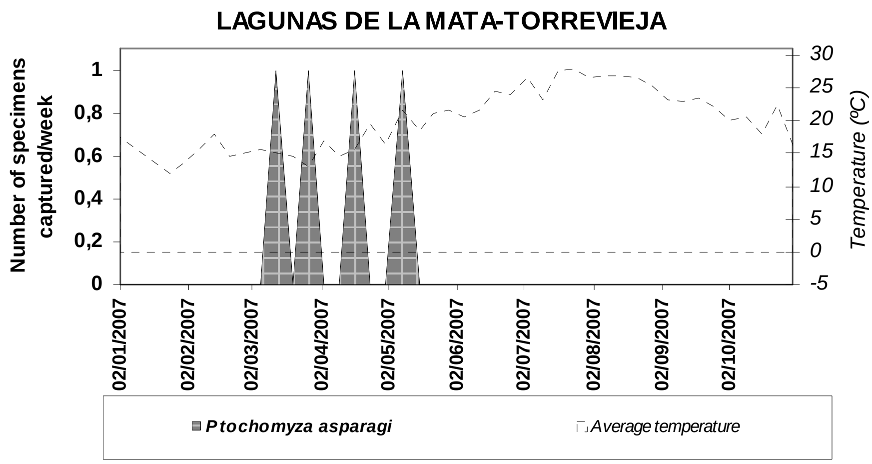


Figure 5-104. Space-time captures evolution of *Ptochomyza asparagi* Hering, 1942 males in Natural Park of "Lagunas de La Mata-Torrevieja".

5.4 New reports for the Agromyzidae

5.4.1 New additions to the biodiversity of Agromyzidae (Diptera) from Spain

Abstract New faunistic data included in 8 Agromyzidae genera are presented. Twenty-two new species collected with Malaise trap are recorded for the first time in Spain: *Agromyza anthracina* Meigen, 1830; *A. bromi* Spencer, 1966; *A. hiemalis* Becker, 1908; *A. megalopsis* Hering, 1933; *Aulagromyza buhri* (de Meijere, 1938); *Au. luteoscutellata* (de Meijere, 1924); *Au. similis* (Brischke, 1880); *Au. trivitatta* (Loew, 1873); *Cerodontha (Poemyza) lapplandica* (Rydén, 1956); *Liriomyza amoena* (Meigen, 1830); *L. erucifolii* de Meijere, 1944; *L. graminivora* Hering, 1949; *L. samogitica* Pakalniškis,1996; *Melanagromyza eupatorii* Spencer, 1957; *M. nibletti* Spencer, 1957; *M. spinulosa* Spencer, 1974; *Ophiomyia labiatarum* Hering, 1937; *O. penicillata* Hendel, 1920; *Phytobia cerasiferae* (Kangas, 1955); *P. lunulata* (Hendel, 1920); *Phytomyza bupleuri* Hering, 1963; and *Ph. tanaceti* Hendel, 1923. In this way, the total number of known species from Spain increases to 287. *M. spinulosa* is presented in a new report for Europe. General information about the host-plants, phenology, development and geographical distribution of Agromyzidae species are included.

Key Words Diptera, Agromyzidae, *Agromyza*, *Aulagromyza*, *Cerodontha*, *Liriomyza*, *Melanagromyza*, *Ophiomyia*, *Phytobia*, *Phytomyza*, host-plants, phenology, new record, Spain, Europe.

Introduction

According to MARTÍNEZ & BÁEZ (2002), the number of Agromyzidae species present in the Spanish fauna was 228. Subsequently, MARTINEZ (2004) updated this number to 245 in the Europaean Fauna database.

Apart from the publications mentioned above, several new species discovered in Spain have been cited by different authors (CERNY, 2004; CERNY, 2006; CERNY & MERZ, 2006; CERNY & VALA, 2006; ZLOBIN, 2000 and ZLOBIN, 2002a). Thus, the number of Spanish Agromyzidae species reach the figure of 265.

This work presents 22 additional species included in 8 genera: *Agromyza*, *Aulagromyza*, *Cerodontha*, *Liriomyza*, *Melanagromyza*, *Ophiomyia*, *Phytobia* and *Phytomyza*. Actually, 287 species is the total number of Agromyzidae fauna in Spain (see additional list to MARTINEZ 2004, attached at the end of this paper).

Despite the Western European Agromyzidae family is greater than 950 species, the equivalent Spanish fauna is very reduced. There is a lack of knowledge of a great part of Agromyzidae in most areas of Europe, North Africa, and the Asian part of the Palaearctic region (CERNY & MERZ, 2006). High monophagy of Agromyzidae and the difficulty of their identification are the main causes.

Material and Methods

Sampling. Malaise Trap is largely used in the world to collect insects and particularly Diptera. In this project the cited system was used for Agromyzidae from 2004 until 2007. Traps were kept permanently in the countryside, except for very cold winters in "Tinença de Benifassà" and "Font Roja" localities. A GPS receiver was used to localize the traps. Samples were taken regularly in weekly basis, and the specimens obtained were preserved in ethyl alcohol 70º. Identifications were carried out with male specimens exclusively, keeping in mind the actual intrinsic difficulty of females' identification.

Information about the biotopes. Three protected areas declared Natural Parks in the Community of Valencia were studied (Fig. 1): the inland mountain ranges "Tinença de Benifassà" (Castellón) and "Font Roja" (Alicante); and the wetland "Lagunas de La Mata-Torrevieja" (Alicante). The particular flora and environmental conditions of each park were the criteries that made think the existence of differences in the Agromyzidae fauna.

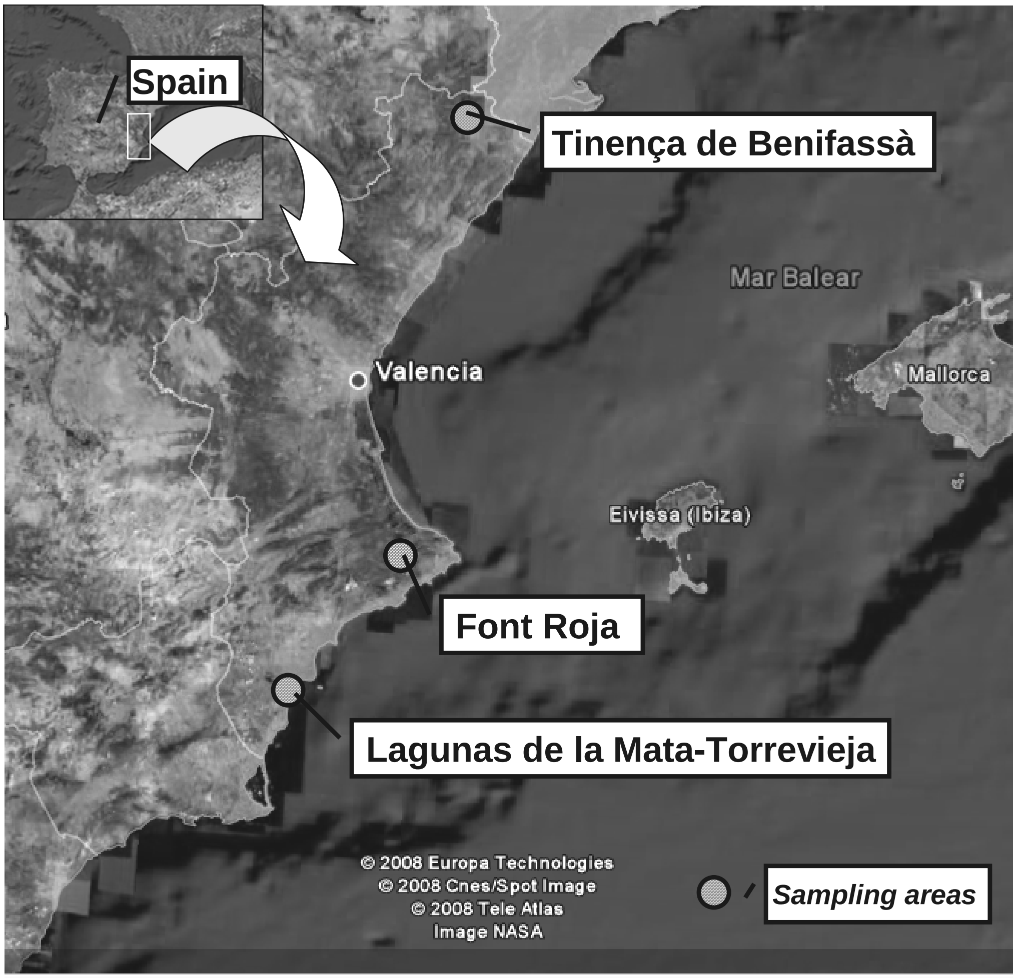


Fig. 1 Geographical location of the South-East Iberian peninsula indicating the location zones of the Malaise traps used in the capture of specimens cited.

Tinença de Benifassà (Castellón): it is located in the Northern part of Community of Valencia bordering on Tarragona and Teruel provinces. The GPS coordinates of the trap were N40º39'22.6" / E00º09'26.8" (Altitude: 680m). Around 25.8 hectares is the surface area of the park, with minimal antropological impact (<250 residents). It presents high faunistic and vegetal biodiversity including well preserved woodlands of pine and oak, scrubland composed by typical mediterranean vegetation including a high number of endemisms, and crop areas. It has typical snowfalls in winter and high temperatures in summer. Annual rainfall is around 450-550 mm.

Font Roja (Alicante): it is located in Alicante province. The GPS coordinates of the trap were N38º39'43.1'' / W00º31'04.0'' (Altitude: 1076m). It is basically a holm oak mountain composed of Tertiary calcareous rocks. The biodiversity of vegetation is high, includes different areas composed of deciduous wood, shady evergreen or holm oak groves, sunny brushwood zones, rock vegetation, rubble vegetation, pine woods and crops. Annual rainfall is around 350-450mm in the Malaise trap zone, with cold winters and high temperatures in summer.

Lagunas de La Mata-Torrevieja (Alicante): it is located in the southern point of the Community of Valencia. The GPS coordinates of the trap were N38º01'48.8" / W00º42'00.1" (Altitude: 5m). It is characterized by saline soils, semiarid climate, annual precipitations lower than 300 mm, and high temperatures. There are salt marsh areas, carrizal-juncal zones, and scrubland. Fresh vegetation is present until mid-May, later the high temperatures (>35ºC) destroy practically all annual plants.

List of new species for Spain and ecological comments

Subfamily Agromyzinae

Genus Agromyza Fallén, 1810

The number of Spanish *Agromyza* species cited by Martinez (2004) is 34. No other species have been found until now. In this paper, four new records are presented for the first time in Spain. Thus, the genus *Agromyza* reach 38 species in Spain.

Agromyza anthracina Meigen, 1830

= *Agromyza freyi* Hendel, 1931

Material examined: Lagunas de La Mata-Torrevieja: 3♂, 14.XII.2004-21.XII.2004; 4♂, 27.XII.2005-03.I.2006; 1♂, 21.XII.2006-28.XII.2006; 1♂, 20.II.2007-06.III.2007.

Distribution: Palaearctic: Belgium, Czeck Republic, Denmark, Finland, France, Germany, Great Britain, Hungary, Ireland, Lithuania, Netherlands, Norway, Poland, Slovakia, Sweden, Switzerland.

Host-plants: *Parietaria*, *Urtica*.

A. anthracina is a monophagous miner in the Urticaceae family and only known in the Palaearctic region. Three other *Agromyza* species were found undermining in *Urtica* in Europe, *A. hiemalis* Becker, 1908, *A. pseudoreptans* Nowakowski, 1967, and

A. reptans Fallén, 1823. *Parietaria* genus is only undermined by two *Agromyza* species, *A. anthracina* and *A. pseudoreptans*.

Phenology: it is present from December until the end of February with average temperatures between 13.8-15.5ºC. Comparing *A. anthracina* captures evolution with total *Agromyza* captures in the Natural Park of "Lagunas de La Mata-Torrevieja" an overlapping is observed. There is a strong seasonality between years, with a maximum of 111 males/week in the end of December of 2004 with an average temperature of 13.8ºC (20ºC max. and 7.5ºC min.). In general *Agromyza* genus is present steadily from mid-November until end of March (Fig. 2).

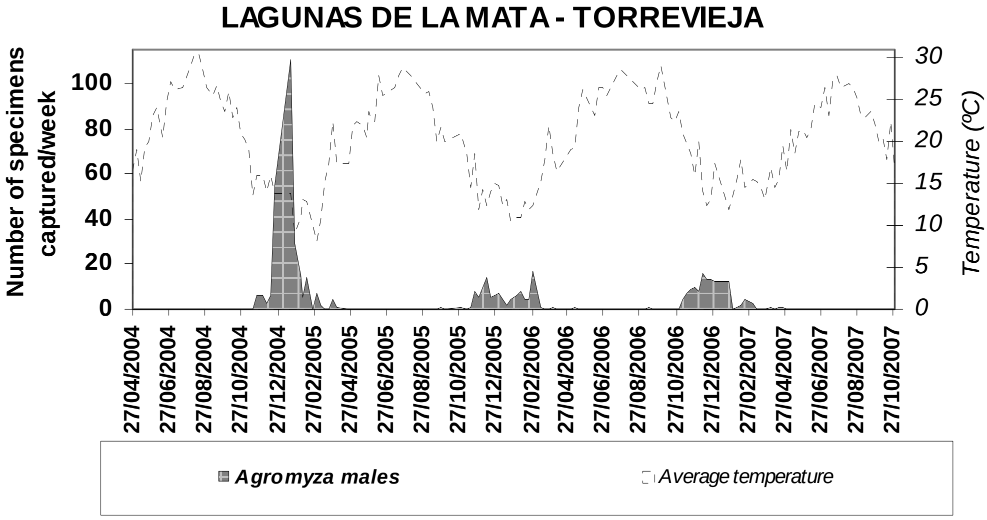


Figure 2. Space-time evolution of total captures of *Agromyza* genus in the Natural Park of "Lagunas de La Mata-Torrevieja".

Agromyza bromi Spencer, 1966

Material examined: Tinença de Benifassà: 2♂, 20.V.2004-27.V.2004; 1♂, 27.V.2004-3.VI.2004; 1♂, 3-10.VI.2004; 1♂, 30.IX.2004-07.X.2004; 1♂, 16.V.2005-23.V.2005; 1♂, 12-19.IX.2005; 3♂, 06.IV.2006-17.IV.2006; 3♂, 24.IV.2006-01.V.2005; 1♂, 1-8.V.2006; 6♂, 8-15.V.2006; 8♂, 15-22.V.2006; 8♂, 22-29.V.2006; 1♂, 29.V.2006-5.VI.2006; 1♂, 11-18.IX.2006; 2♂, 18-25.IX.2006; 3♂, 25.IX.2006-2.X.2006; 14♂, 2-12.X.2006; 5♂, 12-23.X.2006; 1♂, 23-30.X.2006; 2♂, 16.IV.2007-23.IV.2007.

Distribution: Palaearctic: Belgium, Czech Republic, Denmark, France, Germany, Great Britain, Hungary, Lithuania, Poland, Slovakia, Switzerland.

Host-plant: *Bromus*.

The only recorded host is *Bromus catharticus* Vahl (= *Ceratochloa unioloides* (Willd.)) but other grasses are doubtlessly also attacked (CERNY, 2005).

Phenology: this species shows a significant fluctuation throughout the years because of certain environmental conditions and the presence of host-plants. It is mainly distributed in spring, rising by a significant population level from March parallel to the increase in temperature. In 2006, 3 generational peaks were presented in summer reaching a maximum in late May-early June with 8 males/week. There is another generation in autumn registering the highest population peak with 14 males/week. The temperature range that has been observed for the optimal development of *A. bromi* is a fluctuation in daily temperatures between 13ºC (minimum) and 23°C (maximum) (Fig. 3).

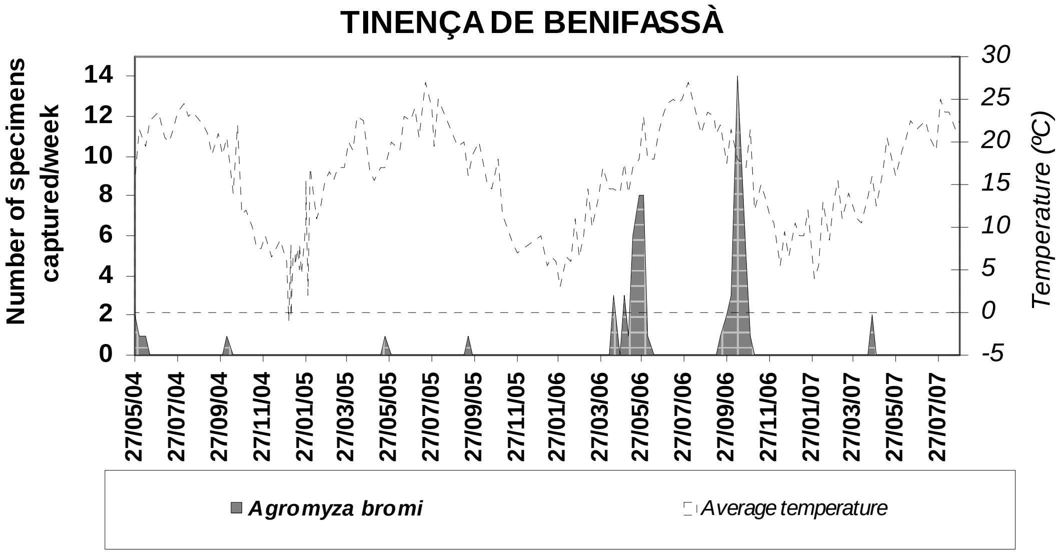


Figure 3. Space-time evolution of *Agromyza bromi* (males only) in the Natural Park of "Tinença de Benifassà".

Agromyza hiemalis Becker, 1908

Material examined: Font Roja: 1♂, 25.IV.2007-30.IV.2007.

Distribution: Palaearctic: France, Greece, Italia, Malta; North Africa, Turkey. This species, restricted to the Mediterranean area, was also recorded in the Balearic and Canary Islands but this is the first citation for continental Spain.

Host-plant: *Urtica*.

Phenology: present in early spring with average temperatures of 14.2ºC.

Agromyza megalopsis Hering, 1933

Material examined: Lagunas de La Mata-Torrevieja: 1♂, 14.XII.2004-21.XII.2004; 4♂, 21.XII.2004-18.I.2005; 2♂, 18-26.I.2005.

Distribution: Palaearctic: Bulgaria, Crete, Czech Republic, France, Greece Germany, Hungary, Poland, Slovakia, "Yugoslavia"; North Africa.

Host-plants: *Hordeum*, *Secale, Triticum*.

Their host-plants belong to the Poaceae family, normally mining *Hordeum*, *Secale* and less frequently *Triticum*. Widespread in Europe, can be a serious pest on barley.

Phenology: Spanish specimens were captured at the beginning of the season in "Lagunas de La Mata-Torrevieja" when daily temperatures were established between 17-20ºC.

Genus ***Melanagromyza*** Hendel, 1920

Forty *Melanagromyza* species have been cited in Spain until now. *Melanagromyza ferulae* Spencer, 1966 was added as a new record from Spain by CERNY & MERZ (2006). In this paper two new records for *Melanagromyza* genus are reported for Spain: *Melanagromyza eupatorii* Spencer, 1957; *M. nibletti* Spencer, 1957; and one for Europe: *Melanagromyza spinulosa* Spencer, 1974.

Melanagromyza eupatorii Spencer, 1957

Material examined: Tinença de Benifassà: 1♂, 27.VI.2005-04.VII.2005; 2♂, 28.VII.2005-1.VIII.2005; 1♂, 8.VIII.2005-2.IX.2005.

Distribution:, Czech Republic, France, Germany, Great Britain, Lithuania, Poland, Slovakia. *M. eupatorii* distribution is exclusively European.

Host-plants: *Eupatorium*, *Inula*, *Leucanthemum*, *Senecio*.

It has been recorded on *Eupatorium cannabium* L., *Inula hirta* L., *Inula conyza* DC., *Leucanthemum vulgare* Lam., and *Senecio* sp. (SPENCER, 1990).

Phenology: occurs in summer when the average temperature range is between 19-25ºC.

Melanagromyza nibletti Spencer, 1957

Material examined: Tinença de Benifassà: 2♂, 24.IV.2006-01.V.2006; 2♂, 19-26.VI.2006; 2♂, 26.VI.2006-3.VII.2006.

Distribution: Palaearctic: Czech Republic, Great Britain.

Host-Plant: *Silaum*.

It was discovered for the first time on *Silaum silaus* (L.) in Southern England (SPENCER, 1990). There is no any other appointment on their host-plants.

Phenology: present from mid-spring to mid-summer with moderate average temperatures (17-23ºC).

Melanagromyza spinulosa Spencer, 1974 (First citation for Europe)

Material examined: Tinença de Benifassà: 3♂, 22.IV.2005-29.IV.2005; 6♂, 29.IV.2005-6.V.2005; 6♂, 16-23.V.2005.

Distribution: Palaearctic: Israel.

Species described from Israel by SPENCER (1974) by means of the capture of 2 males. SPENCER suggests an Ethiopian origin because of the similarity presented of *M. spinulosa* wing venation with *M. curiosa* Spencer, 1959 and *M. cyrtanthi* Spencer, 1960. The latter two are known to be from Africa.

Host-plant: Unknown.

Phenology: present in the Natural Park of "Tinença de Benifassà" from mid-April to late May with moderate average temperatures between 15.5-17ºC. The biggest captures occurred from late April with weekly captures of 6 males/trap. Captures coincide with the period of greatest captures for the entire *Melanagromyza* genus (8-12 males/week) (Fig. 4) essentially set in May. The overall behaviour of *Melanagromyza* in "Tinença de Benifassà" usually consists of 5-6 generations per year concentrated in the spring and summer months. The phenology of females coincides with the period of males flight, but are present in much lower populations.

Comments: this species is characterized by its particular costa not strongly continuous until vein M_{1+2}, which does not occur in any other Palaearctic species of known *Melanagromyza*. The introduction must have been in Europe from North Africa. The ignorance of the host-plants makes it difficult to know the potential location of this species.

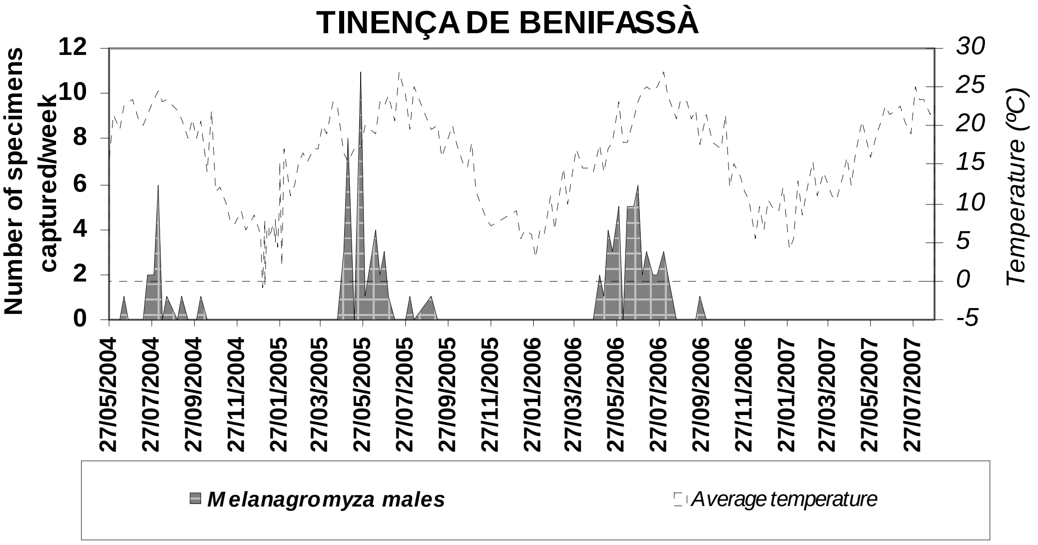


Figure 4. Space-time evolution of total captures of *Melanagromyza* genus in the Natural Park of "Tinença de Benifassà".

Genus ***Ophiomyia*** Bražnikov,1897

The genus *Ophiomyia* is composed of 76 species at Palaearctic level. It is considered more evolutionarily advanced than genus *Melanagromyza*, as well as stem-miners there are also species capable of undermining leaves. Relatively few host-plants are known because of the difficulty of detecting mines. The presence of *Ophiomyia* species is known in two families of monocots, Asparagaceae and Hemerocallidaceae. MARTINEZ (2004) cited the presence of 19 species to which the four abovementioned by CERNY (2006) and CERNY & MERZ (2006) must be added (see Appendix list at the end of the article). The addition of 2 new appointments included in this article

(*Ophiomyia labiatarum* Hering, 1937 and *Ophiomyia penicillata* Hendel, 1920) makes the genus *Ophiomyia* reach 25 species in Spain.

Ophiomyia labiatarum Hering, 1937

Material examined: Tinença de Benifassà: 1♂, 29.VII.2004-05.VIII.2004; 3♂, 22.IV.2005-29.IV.2005; 1♂, 06.VI.2005-13.VI.2005; 1♂, 13-20.VI.2005; 2♂, 27.VI.2005-4.VII.2005; 1♂, 4-11.VII.2005; 1♂, 11-18.VII.2005; 2♂, 15-22.V.2006; 2♂, 22-29.V.2006; 1♂, 29.V.2006-5.VI.2006; 1♂, 5-12.VI.2006; 3♂, 26.VI.2006-3.VII.2006; 1♂, 3-10.VII.2006; 3♂, 10-17.VII.2006; 1♂, 28.VIII.2006-6.IX.2006; 1♂, 6-11.IX.2006; Font Roja: 1♂, 22.V.2006-29.V.2006.

Distribution: Palaearctic: Bulgaria, Czech Republic, Finland, France, Germany, Great Britain, Hungary, Lithuania, Norway, Poland, Slovakia. Nearctic region.

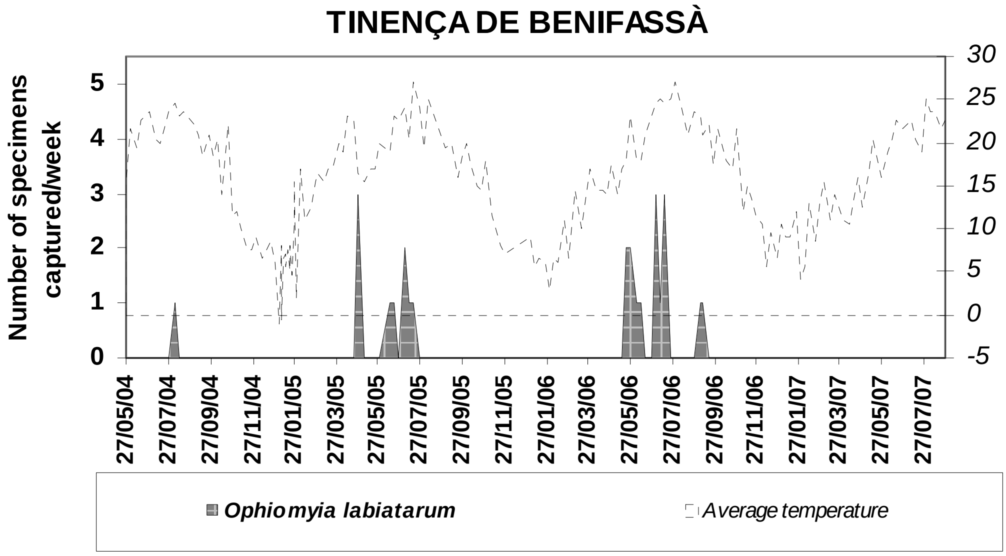


Figure 5. Space-time evolution of *Ophiomyia labiatarum* (males only) in the Natural Park of "Tinença de Benifassá".

Host-plants: *Clinopodium, Galeopsis, Lamium, Leonurus, Nepeta, Prunella, Salvia, Satureja, Scutellaria, Stachys.*

SPENCER (1990) cites *O. labiatarum* as a european species that forms an external stem-mines on *Galeopsis*, *Lamium*, and *Stachys*; and in the Nepetoideae on *Nepeta*, *Prunella* and *Satureja*.

Phenology: this species is present at low population levels (<3 males/week), and whose presence is highly influenced by temperature changes. It is practically present in all seasons except for cold winter months when average temperatures are between 5-10º C, and in the hottest months of summer when daytime temperatures exceed 35º C. Presents 3-4 generations per year with maximum levels during the spring (Fig. 5).

Ophiomyia penicillata Hendel, 1920

Material examined: Tinença de Benifassà: 1♂, 18.IX.2006-25.IX.2006; Font Roja: 1♂, 15.V.2005-23.V.2005.

Distribution: Palaearctic: Austria, Czech Republic, France, Great Britain, Greece, "Yugoslavia".

Host-plant: *Euphorbia.*

This species is only recorded mining Euphorbiaceae.

Phenology: present in autumn in "Tinença de Benifassà" and in mid-spring in "Font Roja". The average temperatures of captures were 22ºC and 16.2ºC respectively.

Subfamily *Phytomyzinae*

Genus ***Aulagromyza*** Enderlein, 1936

Only seven *Aulagromyza* species have been cited in Spain, despite the forty two Palaearctic species described until now in this genus. In this publication four new records for the Spanish fauna are listed: *Aulagromyza buhri* (de Meijere, 1938), *Aulagromyza luteoscutellata* (de Meijere, 1924), *Aulagromyza similis* (Brischke, 1880) and *Aulagromyza trivittata* (Loew, 1873).

Aulagromyza buhri (de Meijere, 1938)

= *Aulagromyza approximatonervis* Frey, 1946
= *Aulagromyza incognita* Hering, 1956
= *Aulagromyza simplonensis* Spencer, 1957

Material examined: Tinença de Benifassà: 1♂, 20.V.2004-27.V.2004; 1♂, 24.IV.2006-1.V.2006; 2♂, 1-8.V.2006.

Distribution: Palaearctic: Belarussia, Estonia, Turkey, Finland, France, Germany, Great Britain, Lithuania, Poland, Slovakia, Switzerland.

Host-plants: *Asperula, Galium.*

External stem-miner.

Phenology: present at low populational levels at the end of spring with moderate average temperatures 14-18ºC.

Aulagromyza luteoscutellata (de Meijere, 1924)

= *Aulagromyza lonicerae* (Brischke, 1880)
= *Aulagromyza lonicerarum* (Frey, 1946)
= *Aulagromyza falleni* (Rydén, 1952)
= *Aulagromyza xylostei* auct.

Material examined: Tinença de Benifassà: 1♂, 26.VI.2006-03.VII.2006.

Distribution: Palaearctic: Belgium, Czech Republic, Denmark, Finland, France, Germany, Lithuania, Republic of Moldova, Netherlands, Norway, Poland, Sweden. Nearctic region.

Host-plants: *Lonicera*, *Symphoricarpos*.

Phenology: present in spring when the average temperatures is 24.5ºC.

Comments: SPENCER (1990) cites *Aulagromyza cornigera* (Griffiths, 1973) and *Aulagromyza luteoscutellata* (de Meijere, 1924), as sister-species. Both species are present in Spain.

Aulagromyza similis (Brischke, 1880)

= *Aulagromyza praecedens* (Strobl, 1898)
= *Aulagromyza centaureana* (Hering, 1925)

Material examined: Tinença de Benifassà: 1♂, 08.V.2006-15.V.2006.

Distribution: Palaearctic: Austria, Belarussia, Czech Republic, Finland, France, Germany, Great Britain, Hungary, Ireland, Italia, Lithuania, Norway, Poland, Romania, Sweden.

Host-plants: *Knautia*, *Succisa*.

Phenology: present in spring when average temperature is 17ºC.

Comments: this is an isolated species, although its genitalia suggest a direct relationship with the species on *Galium* (SPENCER, 1990).

Aulagromyza trivittata (Loew, 1873)

= *Aulagromyza tristriata* (Hendel, 1932)

Material examined: Tinença de Benifassà: 1♂, 2-12.X.2006; 7♂, 12-23.X.2006; 5♂, 23-30.X.2006; 3♂, 30.X.2006-6.XI.2006; 1♂, 29.I.2007-5.II.2007; 1♂, 5-12.II.2007; 2♂, 12-19.II.2007; 1♂, 19-26.II.2007; 8♂, 26.II.2007-5.III.2007; 1♂, 5-12.III.2007; 5♂, 12-20.III.2007; 1♂, 2-9.IV.2007; Lagunas de La Mata-Torrevieja: 1♂, 21.XII.2005-18.I.2005; 5♂, 18-26.I.2005; 3♂, 26.I.2005-2.II.2005; 2♂, 2-8.II.2005; 4♂, 8-15.II.2005; 1♂, 22.II.2005-1.III.2005; 1♂, 1-8.III.2005; 2♂, 13-20.XII.2005; 4♂, 20-27.XII.2005; 3♂, 27.XII.2005-3.I.2006; 5♂, 3-10.I.2006; 4♂, 10-17.I.2006; 1♂, 17-24.I.2006; 5♂, 24-31.I.2006; 4♂, 31.I.2006-7.II.2006; 6♂, 7-14.II.2006; 2♂, 14-21.II.2006; 1♂, 21-28.III.2006; 1♂, 12-19.XII.2006; 2♂, 19-26.XII.2006; 6♂, 26.XII.2006-2.I.2007; 1♂, 24-30.I.2007; 1♂, 6-13.II.2007; 1♂, 13-20.II.2007; 1♂, 6-13.III.2007.

Distribution: Palaearctic: Austria, Belarussia, Czech Republic, Denmark, Estonia, France, Germany, Great Britain, Hungary, Ireland, Latvia, Lithuania, Netherlands, Norway, Poland, Romania, Slovakia, Sweden, Switzerland,

Host-plant: *Galium*.

This is a monophagous species whose larvae feeds as internal stem-borer on *Galium mollugo* L.

Phenology: it has been captured in both, “Tinença de Benifassà” and “Lagunas de La Mata-Torrevieja”. In “Tinença de Benifassà” (Fig. 6) shows a large seasonality between years and has only been captured at the end of 2006 and 2007. Presents 3-5 generations per year mainly concentrated in the spring. The largest population peaks (8 males/week) are produced at the beginning of March and late October (7 males/week). The largest captures occur when average temperatures are between 15-17ºC. In “Lagunas de La Mata-Torrevieja” (Fig. 7) this species is found regularly during the years studied, presenting between 3-5 generations per year concentrated in winter when the average temperature does not exceed 15ºC. The maximum capture levels were 6 flies/week and have been since early January to mid-February.

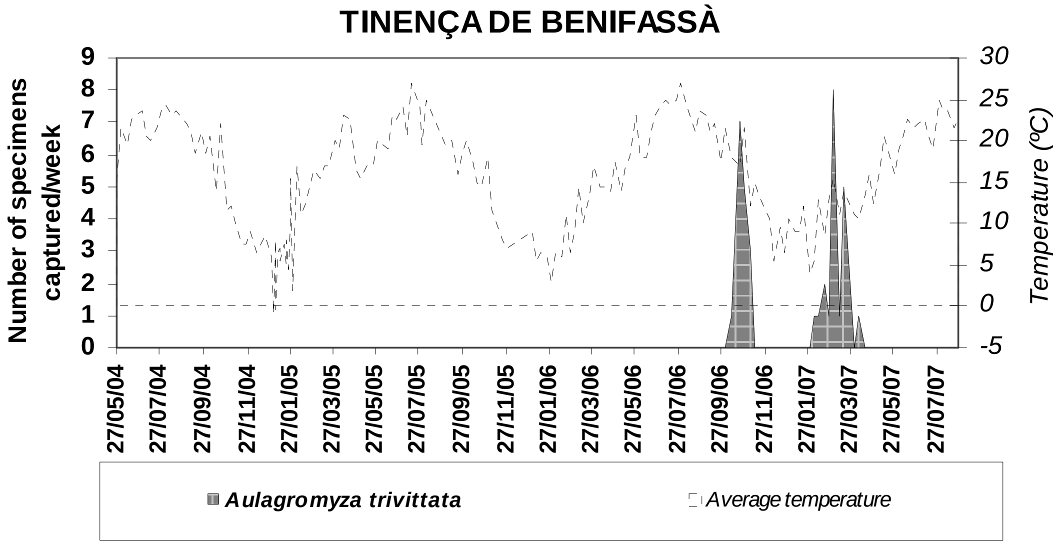


Figure 6. Space-time evolution of *Aulagromyza trivittata* (males only) in the Natural Park of “Tinença de Benifassá”.

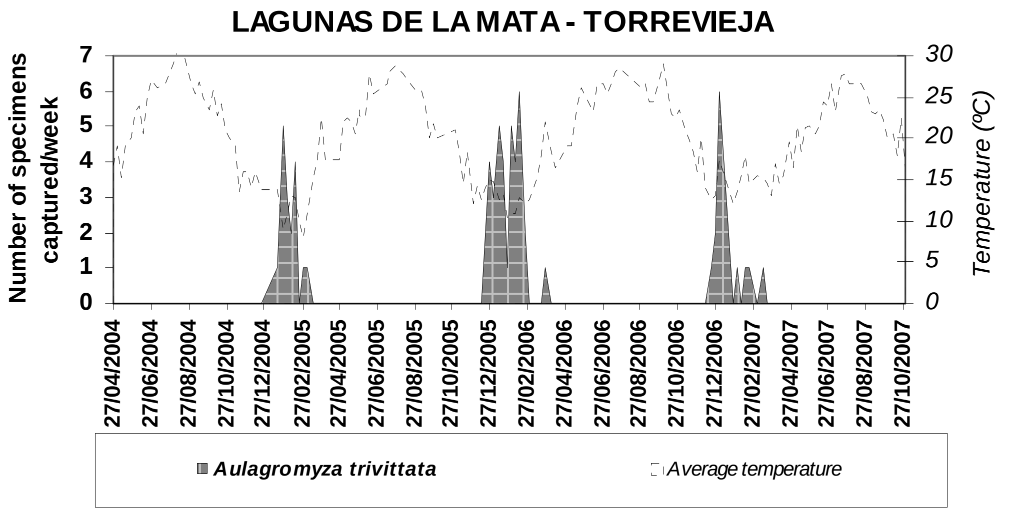


Figure 7. Space-time evolution of *Aulagromyza trivittata* (males only) in the Natural Park of “Lagunas de La Mata-Torrevieja”.

Genus ***Cerodontha*** Rondani, 1961

Genus *Cerodontha* is composed of 7 subgenera: *Butomomyza* Nowakowski, 1967 (10% of the Palaearctic species); *Cerodontha* Rondani, 1861 (16%); *Dizygomyza* Hendel, 1920 (22%); *Icteromyza* Hendel, 1931 (8%); *Phytagromyza* Hendel, 1920 (<1%); *Poemyza* Hendel, 1931 (37%); and *Xenophytomyza* Frey, 1946 (6%). MARTINEZ (2004) cited the presence of 24 species in Spain. CERNY & MERZ (2006) includes two new appointments: *Cerodontha (Xenophytomyza) atronitens* (Hendel, 1920) and *Cerodontha (Dizigomyza) fasciata* (Strobl, 1880). Actually the Spanish fauna consists of 27 species including the above-mentioned in this article: *Cerodontha (Poemyza) lapplandica* (Rydén, 1956).

Cerodontha (Poemyza) lapplandica (Rydén, 1956)

= *Cerodontha (Poemyza) tatrica* Nowakowsky, 1967

Material examined: Tinença de Benifassà: 1♂, 29.IV.2005-06.V.2005; 1♂, 03.VII.2005-10.VII.2005.

Distribution: Palaearctic: Czech Republic, Estonia, Germany, Great Britain, Lithuania, Norway, Poland, Slovakia, Sweden.

Host-plants: *Calamagrostis, Festuca.*

Phenology: present in spring and summer in “Tinença de Benifassà” when average temperature ranges between 15.5-20.5ºC.

Genus ***Liriomyza*** Mik, 1894

Liriomyza is the second genus with the highest number of species within the Agromyzidae family. Actually, it has 147 Palaearctic species. In Spain 36 species have been cited by MARTINEZ (2004). ZLOBIN (2002b) added three new species for Spain: *Liriomyza aculeolata* Zlobin, 2002; *L. europaea* Zlobin, 2002 and *L. pedestris* Hendel, 1931. Also *Liriomyza polygalae* Hering, 1927 was added by CERNY & MERZ (2006). It is cited below *Liriomyza amoena* (Meigen, 1830); *L. erucifolii* de Meijere, 1944; *L. graminivora* Hering, 1949 and *Liriomyza samogitica* Pakalniškis, 1996 like new for Spain. Now the number of *Liriomyza* species in Spain is 44.

Liriomyza amoena (Meigen, 1830)

Material examined: Tinença de Benifassà: 1♂, 22.VII.2004-29.VII.2004.

Distribution: Palaearctic: Belgium, Czech Republic, Demark, Turkey, Finland, France, Germany, Great Britain, Lithuania, Madeira, Republic of Moldova, Poland, Romania, Slovakia, Sweden, Netherlands. Oriental region.

Host-plant: *Sambucus*.

Phenology: found punctually in mid-summer in “Tinença de Benifassà” when average temperature is 23.5ºC.

Liriomyza erucifolii de Meijere, 1944

= *Liriomyza senecifolii* Hering, 1944

Material examined: Tinença de Benifassà: 1♂, 17-24.IV.2006; 1♂, 15-22.V.2006; 7♂, 22-29.V.2006; 1♂, 03.VII.2006-10.VII.2006; 1♂, 24.VII.2006-1.VIII.2006; 2♂, 20.VIII.2006-28.VIII.2006; 1♂, 25.IX.2006-2.X.2006; 2♂, 2-12.X.2006; 4♂, 12-23.X.2006.

Distribution: Palaearctic: Czech Republic, Denmark, France, Germany, Great Britain, Poland, Netherlands.

Host-plant: *Senecio.*

Six *Liriomyza* species are restricted in the Senecioneae: *Liriomyza latigenis* (Hendel, 1920); *L. erucifolii*; *L. samogitica* Pakalniškis 1996**;** *L. sonchi* Hendel, 1931 and *L. kleineae* Hering, 1927. *L. erucifolii* forms linear mines inside *Senecio erucifolius* L. and *S. jacobea* L.

Phenology: there have been only captures in 2006 in the Natural Park of “Tinença de Benifassà”, observing the presence of 6 generations distributed from mid-spring to mid-autumn. The highest population peak has occurred in late May with 7 males/week, and mid-October with 4 males/week. The optimum average temperature range of development is established between 20-25ºC (Fig. 8).

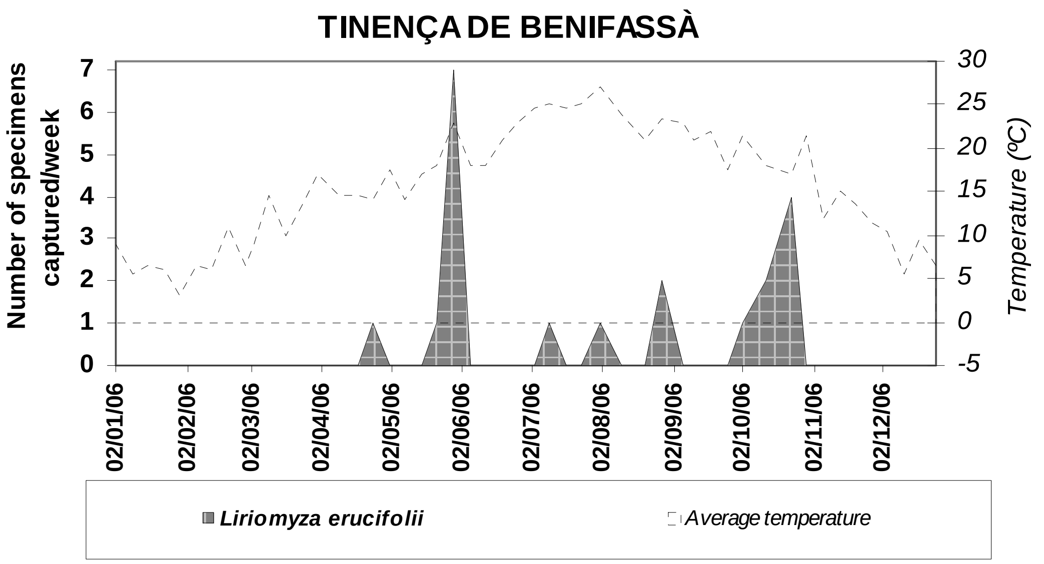


Figure 8. Space-time evolution of *Liriomyza erucifolii* (males only) in the Natural Park of “Tinença de Benifassà”.

Liriomyza graminivora Hering, 1949

Material examined: Tinença de Benifassà: 1♂, 06.IV.2006-17.IV.2006; 1♂, 17.IV.2006-24.IV.2006.

Distribution: Czech Republic, Germany, Lithuania, Poland, Slovakia.

Host-plants: *Hordeum*, *Poa*.

Phenology: low levels of captures were registered in "Tinença de Benifassà" in spring when the average temperatures range is 15-17ºC.

Comments: the male genitalia shows a close relationship with the more widespread species *Liriomyza orbona* (Meigen, 1830) and *Liriomyza pedestris* Hendel, 1931.

Liriomyza samogitica Pakalniškis 1996

Material examined: Lagunas de La Mata-Torrevieja: 1♂, 21-28.III.2006; 1♂, 28.III.2006-4.IV.2006.

Distribution: Palaearctic: Lithuania.

Host-plant: *Senecio.*

Liriomyza samogitica is a monophagous species mining *Senecio* within the Compositae family.

Phenology: present in spring at low levels of capture in "Lagunas de La Mata-Torrevieja" when average temperature range is 16-18ºC.

Genus ***Phytobia*** Lioy, 1864

So far only two *Phytobia* species have been cited in Spain (MARTINEZ, 2004). Twelve species of this genus are present in the Palaearctic region (ZLOBIN, 2008). In this paper two new records are added to Spanish fauna: *Phytobia cerasiferae* (Kangas, 1955) and *Phytobia lunulata* (Hendel, 1920).

Phytobia cerasiferae (Kangas, 1955)

Material examined: Tinença de Benifassà: 1♂, 29.V.2006-05.VI.2006.

Distribution: Czech Republic, Finland, France, Germany, Great Britain, Russia.

Host-plant: *Prunus*.

It was described from *Prunus cerasifera* Ehrh., and other *Prunus* in England.

Phenology: captured punctually in "Tinença de Benifassà" in spring with maximum and minimum temperatures of 26º-10ºC respectively. The low level presence of *P. cerasiferae* is due to the existence of *Prunus* crops at too great a distance in order to make the captures effective. The main crop of *Prunus* in the zone is *Prunus cerasifera* Ehrh.

Phytobia lunulata (Hendel, 1920)

Material examined: Font Roja: 1♂, 03.VI.2004-10.VI.2004; Lagunas de La Mata-Torrevieja: 1♂, 27.III.2007-03.IV.2007.

Distribution: Austria, Czech Republic, France, Germany, Slovakia.

It is a stem-miner cited and widely present in the European continent. It is present in a continuous form from central Europe to France, where this species has certainly entered Spain. The host-plants ignorance of this miner is surprising due to its widespread distribution.

Host-plant: Unknown.

Phenology: present in spring exclusively in “Font Roja” and “Lagunas de La Mata-Torrevieja” when the average temperatures are around 19ºC and 17ºC, respectively.

Genus ***Phytomyza*** Fallén, 1810

It is considered the most widely represented genus of Agromyzidae, constituting about 30% of total known Palaearctic species (1160 species). MARTINEZ (2004) cited the presence of 282 species in Europe and 46 in Spain. Two new *Phytomyza* species were reported later in Spain: *P. (Phytomyza) hellebori* Kaltenbach, 1872 (*anemones* group) (CERNY & MERZ, 2006) and *P. (Phytomyza) petoei* Hering, 1924 (*petoei* group) (CERNY & VALA, 2006). *Phytomyza bupleuri* Hering, 1963 and *P. tanaceti* Hendel, 1923 new for the Spanish fauna are cited below, constituting a total of 50 species.

Phytomyza bupleuri Hering, 1963

Material examined: Font Roja: 1♂, 02.V.2005-09.V.2005.

Distribution: Palaearctic: Germany

Host-plant: *Bupleurum.*

Phenology: found punctually in spring in “Font Roja”. The average of maximum and minimum temperatures during the week in which the specimen cited was captured were 27.5ºC and 15ºC, respectively.

Comments: SPENCER (1990) considers *P. blupleuri* species derived from an ancestor in the Ranunculaceae together with other close species like *Napomyza bellidis* Griffiths, 1967 and *N. lyalli* (Spencer, 1976).

Phytomyza tanaceti Hendel, 1923

Material examined: Font Roja: 1♂, 02.V.2005-09.V.2005.

Distribution: Palaearctic: Austria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Great Britain, Ireland, Lithuania, Norway, Poland, Slovakia, Sweden.

Probably widespread in Europe, closely resembling *Phytomyza ptarmicae* Hering, 1937 but with distinctive differences in male genitalia.

Host-plants: *Achillea, Tanacetum.*

Phenology: found punctually in spring in the same period that *Phytomyza bupleuri* with average temperatures of 21.2ºC, suggesting they have very similar conditions of development.

Discussion

This paper cites twenty-two new records for the Spanish Agromyzidae fauna. The current number of Agromyzidae species in Spain is 287. Approximately, it represents only 30% of the European species, and 20% of Palaearctic region. Other countries located in different geographical areas of Europe present similar percentages like Italy (23% of European species), Great Britain (42%) or Lithuania (44%). Central Europe has been studied a little more like for example Germany (62%).

In reference to the Palaearctic region, approximately 82% of 1160 total species are known to be present in Europe. Comparatively the distribution of Spanish species is poor. In this way, the percentage of distribution of genera in Spain listed in this publication is as follows: *Agromyza* (38%), *Aulagromyza* (24%), *Liriomyza* (28%), *Melanagromyza* (29%), *Phytobia* (24%) and *Pseudonapomyza* (21%). Is obvious the important work that all Agromyzidae specialists have to do it to know the real Agromyzidae fauna in Europe.

Particularly important is the citation of new reports of *Phytobia* genus due to the existence of only 2 species -*Phytobia carbonaria* (Zetterstedt 1848) and *Phytobia errans* (Meigen 1830)- referred to Spain. Now two more *Ph. cerasiferae* and *Ph. lunulata* it is included. The limited knowledge of the biology of these stem-borers is the main difficulty of damage detection and phytophagous obtaining.

The species reported in this paper is basically monophagous or oligophagous, showing in general low populations. Plant mined families belong to Adoxaceae (*Liriomyza amoena*), Apiaciae (*Phytomyza bupleuri*), Asteraceae (*Liriomyza erucifolii*, *L. samogitica*, *Melanagromyza eupatorii* and *Phytomyza tanaceti*), Caprifoliaceae (*Aulagromyza luteoscutellata*), Dipsacaceae (*Aulagromyza similis*), Euphorbiaceae (*Ophiomyia penicillata*), Lamiaceae (*Ophiomyia labiatarum*), Poaceae (*Agromyza bromi*, *A. megalopsis*, *Cerodontha (Poemyza) lapplandica*, *Liriomyza graminivora*), Rosaceae (*Phytobia cerasiferae*), Rubiaceae (*Aulagromyza buhri*, *Au. trivittata*), Umbelliferae (*Melanagromyza nibletti*) and Urticaceae (*Agromyza hiemalis*). Being the botanical families with the greatest number of botanical species (mainly Asteraceae and Poaceae) the most represented with Agromyzidae miners.

Prevailing environmental conditions in the different presented genera are in a range between 15-25ºC of average temperatures. Below 10°C and above 30ºC, captures of Agromyzidae are practically null. Although there is a clear seasonality with the evolution of temperatures, the host-plants of Agromyzidae are the key factor of presence and possibility of development of the populations of Agromyzidae. Periods of maximum captures in the Natural Parks of "Tinença de Benifassà" and "Font Roja" occur from mid spring-early summer to late summer-beginning autumn, while in "Lagunas de La Mata-Torrevieja" captures were higher from mid winter to late spring. The benign winters in "Lagunas de La Mata-Torrevieja" and high daytime temperatures (>35ºC) recorded in summer make the development of the vegetation is temporarily moved, with a significant decline in the existence of broad-leaved plants from mid-spring.

The appendix included in this article updates the list of species presented in the spanish catalog (MARTINEZ, 2004), including a total of 42 new reports. Especially important is the citation of *Melanagromyza spinulosa* for the European continent. During the study carried out by our team, we can affirm the presence in the Natural Park of "Tinença de Benifassà" of *Amauromyza (Cephalomyza) karli*, *Chromatomyia succisae* (also found in "Font Roja"), *Metopomyza scutellata* and *Ophiomyia orbiculata*. Species reported previously by CERNY and ZLOBIN (see appendix below).

This study increases the number of species recorded in Spain significantly, although we think that the presence of Agromyzidae in Spain is more represented, and especially by a great number of species new for science that in general tend to be found in low populations. Anyway there is a predominance of the existence of polyphagous Agromyzidae species. They are normally found in great amounts with species like *Ophiomyia beckeri* (Hendel, 1923), *Chromatomyia horticola* (Goureau, 1851), and a large number of species of the genus *Liriomyza* stressing *L. brassicae* (Riley, 1884), *L. congesta* (Becker, 1903), *L. strigata* (Meigen, 1830), and *L. trifolii* (Burgess *in* Comstock, 1880).

Appendix:

List of new Agromyzidae records from Spain added to Martinez (2004)

Agromyza anthracina Meigen, 1830 (present publication)
Agromyza bromi Spencer, 1966 (present publication)
Agromyza hiemalis Becker, 1908 (present publication)
Agromyza megalopsis Hering, 1933 (present publication)
Amauromyza (Cephalomyza) karli (Hendel, 1927) (CERNY & MERZ, 2006: 87)
Amauromyza (Cephalomyza) luteiceps (Hendel, 1920) (CERNY & MERZ, 2006: 87)
Aulagromyza buhri (de Meijere, 1938) (present publication)
Aulagromyza luteoscutellata (de Meijere, 1924) (present publication)
Aulagromyza similis (Brischke, 1880) (present publication)
Aulagromyza trivittata (Loew, 1873) (present publication)
Cerodontha (Dizigomyza) fasciata (Strobl, 1880) (CERNY & MERZ, 2006: 89)
Cerodontha (Poemyza) lapplandica (Rydén, 1956) (present publication)
Cerodontha (Xenophytomyza) atronitens (Hendel, 1920) (CERNY & MERZ, 2006: 91)
Chromatomyia succisae (Hering, 1922) (CERNY & VALA, 2006: 38)
Liriomyza aculeolata Zlobin, 2002 (ZLOBIN, 2002b: 149)
Liriomyza amoena (Meigen, 1830) (present publication)
Liriomyza erucifolii de Meijere, 1944 (present publication)

Liriomyza europaea Zlobin, 2002 (ZLOBIN, 2002b: 152)
Liriomyza graminivora Hering, 1949 (present publication)
Liriomyza pedestris Hendel, 1931 (ZLOBIN, 2002b: 164)
Liriomyza polygalae Hering, 1927 (CERNY & MERZ, 2006: 95)
Liriomyza samogitica Pakalniškis, 1996 (present publication)
Melanagromyza eupatorii Spencer, 1957 (present publication)
Melanagromyza ferulae Spencer, 1966 (CERNY & MERZ, 2006: 82)
Melanagromyza nibletti Spencer, 1957 (present publication)
Melanagromyza spinulosa Spencer, 1974 (present publication)
Metopomyza scutellata (Fallén, 1823) (CERNY & MERZ, 2006: 95)
Ophiomyia inaequabilis (Hendel, 1931) (CERNY & MERZ, 2006: 84)
Ophiomyia labiatarum Hering, 1937 (present publication)
Ophiomyia nasuta (Melander, 1913) (CERNY, 2006: 22)
Ophiomyia orbiculata (Hendel, 1931) (CERNY, 2006: 22)
Ophiomyia penicillata Hendel, 1920 (present publication)
Ophiomyia vimmeri Zlobin, 1994 (CERNY & MERZ, 2006: 86)
Phytobia cerasiferae (Kangas, 1955) (present publication)
Phytobia lunulata (Hendel, 1920) (present publication)
Phytoliriomyza dorsata (Siebke, 1864) (ZLOBIN, 2005: 1)
Phytoliriomyza immoderata Spencer, 1963 (CERNY & MERZ, 2006: 97)
Phytomyza (Phytomyza) bupleuri Hering, 1963 (present publication)
Phytomyza (Phytomyza) hellebori Kaltenbach, 1872 (CERNY & MERZ, 2006: 99)
Phytomyza (Phytomyza) petoei Hering, 1924 (CERNY & VALA, 2006: 40)
Phytomyza (Phytomyza) tanaceti Hendel, 1923 (present publication)
Pseudonapomyza europaea Spencer, 1973 (CERNY, 2004: 98)

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5.4.2 First record of *Melanagromyza sojae* (Zehnter, 1900) (Diptera: Agromyzidae) in Europe

Abstract A new Agromyzidae (Diptera) pest is reported in Spain, *Melanagromyza sojae* (Zehnter, 1900). The stem-miner was captured with Malaise trap in "Tinença de Benifassà" (Castellón). Information is given about distribution, damage, control, host-plants, biology and ecology of this pest. Identification rules are indicated for its distinction from the rest of Agromyzidae miners on soybean in Europe.

Key Words Diptera, Agromyzidae, *Melanagromyza sojae*, New record, Spain, Europe.

Introduction

Throughout 2004-2007 a study of biodiversity was carried out in the Natural Park of "Tinença de Benifassà". As a result of identifications made the presence of *Melanagromyza sojae* (Zehnter, 1900) was detected in Malaise trap. While only a single male was captured, the presence indicates the existence of *M. sojae* in Spain possibly from the Palaearctic Eastern region. The detection occurred at the beginning of autumn (18/09/2006-25/09/2006) at a height of 755 m. and located in the GPS coordinates N40º39'22.6" / E00º09'26.8".

According to Martinez 2004, *M. sojae* is distributed in Afrotropical, Australian, Palaearctic and Oriental regions. Constituting the presence of *M. sojae* in Spain the first appointment for Europe. *M. sojae* is essentially an Oriental species, but it reaches Egypt and Israel (SPENCER, 1990). Its known distribution includes Australia, China, Egypt, India, Indonesia, Israel, Japan, Laos, Malaysia, Micronesia, Philippines, Saudi Arabia, Salomon Islands, South Africa, South Korea, Taiwan, Thailand and Vietnam.

M. sojae is considered an important stem-miner pest of leguminosae crops. According to SPENCER (1990), its primary host is *Glycine*, but this specie is highly oligophagous, and it has also been recorded on other genera (listed in host-plants section).

Recognition criteria

In the Palaearctic region only the stem-miner *Ophiomyia phaseoli* (Tryon, 1895) can attack the soybean at the same time as *M. sojae*, and *O. phaseoli* has only been recorded from European Turkey. These insects can be easily distinguished in the larval and pupal stages by locating their feeding and pupation sites within the host plant. The behaviour of *Ophiomyia* larvae is feeding close to the surface (cortex feeders), pupating in the cortex just beneath the stem epidermis; while *M. sojae* larvae feeds the pith internally (pith feeders), boring down to the root and then again feeding upwards until it is fully-grown, and finally pupate in the pith. Both species can also be distinguished by the morphology of their posterior spiracles in both larval and pupal stages (TALEKAR, 1990). In *O. phaseoli*, the posterior spiracles closely adjoin on conical projections having about 10 minute bulbs, while in *M. sojae* are well separated and normally consist of six raised pores around a central truncated horn. Other agromyzids can damage the same *M. sojae* hosts, *Liriomyza congesta* (Becker, 1903), *Liriomyza trifolii* (Burgess in Comstock, 1880), *Chromatomyia horticola* (Goureau, 1851), *Agromyza frontella*

(Rondani, 1875), *Agromyza nana* Meigen, 1830, *Liriomyza huidobrensis* Blanchard, 1926, *Liriomyza strigata* (Meigen, 1830), *Liriomyza xanthocera* (Czerny *in* Czerny and Strobl 1909), but these species only mine the leaves.

M. sojae is characterized by whitish eggs, translucent, oval, with sizes estimated around 0.34 ± 0.02 mm in length and 0.15 ± 0.01 mm in width (LEE, 1976 and WANG, 1979). The young larva is nearly colourless and causes tiny holes at the base of the leaf lamina. On cutting open, stems are seen to contain dark red to brownish feeding damage in the pith and larvae or pupae in the feeding tunnels. The peculiar shape, size and nature of sclerotization of posterior spiracular bulbs can be used in identification. The anterior spiracles are short and knoblike, with eight minute pores. Posterior spiracles are well separated and normally consist of six raised pores around a central truncated horn. The pupa is cylindrical, yellowish-brown, and measures 2.75 mm long and is 1.00 mm wide (SINGH, 1982). SPENCER (1973) gives details of other morphological characters.

M. sojae genitalia is illustrated in Fig. 1, but normally identification isn't necessary if the damaged plant is present, because other competitive stem-miners are lacking in the Palaearctic region with the same behaviour.

Figure 1. *Left*. Adult male. *Center*. Genitalia in side view. *Right*. Genitalia in ventral view.

Host-plants

M. sojae is highly oligophagous and their host-plants belong to Leguminosae family. It was recorded in Java on *Indigofera*, *Swainsona*, *Cajanus*, *Flemingia*, and *Aeschynomene*. Also it was found in Egypt on *Medicago*, and in India on *Melilotus* SPENCER (1990). Agromyzidae preference for plants is greatly related to their chemistry, thus ensuring wide acceptability as hosts (POLHILL & RAVEN, 1981).

The range of botanical species known to be mined by *M. sojae* is included in 13 botanical genera: *Aeschynomene indica* L. (indian jointvetch), *Astragalus sinicus* L. (chinese milk-vetch), *Cajanus cajan* (L.) Millsp. (pigeon pea), *Crotalaria juncea* L. (sunn hemp), *Flemingia sp.*, *Glycine max* (L.) Merr. (soybean), *Glycine soja* Sieb and Zucc. (wild soybean), *Indigofera suffruticosa* Mill. (anil de pasto), *Indigofera tinctoria* L. (true indigo), *Medicago polymorpha* L. (burclover), *Medicago sativa* L. (alfalfa), *Melilotus* sp., *Phaseolus vulgaris* L. (kidney bean), *Pisum sativum* L. (garden pea), *Stizolobium* sp., *Swainsonia galegifolia* (And.) R.Br. (smooth darling pea), *Vigna aconitifolia* (Jacq.) Marechal (moth bean), *V. angularis* (Willd.) Ohwi & Ohashi (adzuki bean), *V. mungo* (L.) Hepper (black gram), *V. radiata* (L.) R. Wilczek. (mung bean), *V. unguiculata* (L.) Walp. subsp. *sesquipedalis* (L.) Verdc. (yardlong bean), *V.*

umbellata (Thunb.) Ohwi & H. Ohashi (rice bean), and *V. unguiculata* (L.) Walp. (blackeyed pea).

In the Palaearctic region *M. sojae* damaged flora is included in the genera *Glycine*, *Medicago*, *Melilotus*, *Phaseolus*, *Pisum* and *Vigna*. Some of these genera include important leguminosae cultured species as soybean, beans, and pea. The genera *Medicago* and *Melilotus* are species used as forage crop for cattle.

Damages and control

According to SPENCER (1973) infestation in soybean occurs in the unifoliate or early trifoliate leaf stage. By this stage, the seedlings are well established and the insect infestation rarely results in plant mortality.

Damages produced by *M. sojae* are variable depending on the crop, the varietal plant, environment, cultural methods, and plant growth stage when infestation occurs. Yield reduction only occurs when the plant is damaged at the seedling stage. When later the damage is produced the yield loss is lower.

Infestations are reported higher than 80% on soybean (BERG *et al.*, 1998). PAN & PAN (1996) reported yield loss is 33% in the 4th generation, and KUNDU & SEKHAR (1995) cites losses from 18-40% depending on varietal species. VANKATESAN & KUNDU (1994) found a significant negative correlation between agromyzid infestation and grain yield with losses of 2.7-3.8 g of weight per plant.

It is also reported that the attacks on soybean plants by *M. sojae* conclude with a significantly reduction in plant height, leaf area, dry matter accumulation, leaf moisture content, number of branches per plant, *Rhyzobium* nodules and nodule weight, number of pods per plant, number of seeds per pod, and seed yield (TALEKAR, 1989).

M. sojae external damage is shown in the form of feeding punctures made on the upper side of the leaves. In older plants two separate tunnels normally appear corresponding with an early infestation in unifoliate leaves, and other when the plant is higher in trifoliate leaves.

In the last three decades more than 100 studies have been reported for establishing a system of control for this pest. The most common applied systems are the use of foliar and seed insecticides (ELBADRY *et al.* 2006, DEY *et al.* 2006, SALUNKE *et al.*, 2004, PURWAR & YADAV, 2004 and KESHBHAT *et al.* 2004) and the use of varietal resistance (JADHAV *et al.* 2006, TAWARE *et al.* 2005, MANOJ *et al.* 2005 and GUPTA *et al.* 2004).

Other possibilities of control are the use of parasitoids (e.g. Pteromalidae, Eucoilinae, and Braconidae families) (JAYAPPA, *et al.* 2002, ABE & KONISHI, 1995 and BERG, *et al.* 1995) as a complement to other systems as its still not completely effective by itself.

Other multiple systems have been developed but without completely effective results. Microbial agents use (DUBEY *et al.,* 1998), radiation (SHARMA *et al.*, 1996), rice-straw mulch (HIRANO *et al.*, 1993), contaminant nematodes (CHAWLA *et al.*, 1990), and neem products (KUNDU & TRIMOHAN, 1992), have been tested by several authors. Intercropping, weed management, modification of plant density or phenolic and tanin contents modification, are other examples.

Biology and ecology

Oviposition normally occurs on the outside of the young leaves at the basal part near the petiole. The eggs number ranges from 1-6 depending on adult population density. Egg hatch begins on the second day, and can last up to the seventh day after oviposition (WANG, 1979).

The larva behaviour consists of tunnelling the mesophyll tissue into the closest vein until arriving into the stem. The larva feeds on the pith, where pupation also takes place. The full grown larva mines through the xylem and phloem tissue in order to make a hole on the outside. This hole is closest with debris, place where the emerging adult occurs (van der GOOT, 1930). SINGH (1982) reports the duration of the three larval instars at 32 ± 2°C and 70% RH as follows: first instar 22 hours, second instar 43 hours, and third instar 98 hours. The total duration of the larval stage was 7 days. The natural mortality for larvae is very high, WANG (1979) found that of 100 eggs only 1.9 adults emerged.

The pupa is always located near the fly escape hole, seen as a dark depression. The pupal stage ranges from 6-12 days. In Indonesia it is reported that the time from egg to adult is 16 to 26 days, with an average of 21 days (van der GOOT, 1930). Copulation occurs 3 to 5 days after adult emergence only in the morning from 7 to 10 hours. Oviposition begins soon after copulation and lasts for 19 days (WANG, 1979).

M. sojae adult activity is strongly influenced by the weather. This species feeds on plant juices from oviposition and feeding holes made in the leaves by females, dew drops, and other similar moist materials.

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5.4.3 *Pseudonapomyza atratula* Zlobin, 2002 (Diptera: Agromyzidae) new species for the European continent (Spain)

Abstract *Pseudonapomyza atratula* Zlobin, 2002 (Diptera, Agromyzidae) a earlier species only known from Tunisia is reported for the first time in Europe (Spain). Their host-plants, *Avena barbata* Pott ex Link and *A. fatua* L., are indicated here for the first time. *Pseudonapomyza atratula* belongs to the same group of species as *P. atra* (Meigen, 1830); morphological criteria are given to separate these two closely connected species, in particular on the genitalia of the males. Some biological and phenologic elements are also given for *P. atratula*.

Key Words Diptera, Agromyzidae, *Pseudonapomyza*, new report, Spain, Europe.

General and faunistical considerations on the genus *Pseudonapomyza*

Genus *Pseudonapomyza* Hendel, 1920 is composed, in the European continent, exclusively of miners on Monocotyledon plants (Poaceae). *Pseudonapomyza* is considered to have emerged from the genus *Phytomyza* in which it is included 28.5% of Palaearctic Agromyzidae species. Within *Pseudonapomyza* it is a distinguished group undermining within Acanthaceae, Amaranthaceae and Asteraceae; while there is another group that is colonizing the temperate zones and include exclusive miner species on Poaceae (SPENCER, 1990).

Pseudonapomyza is widely distributed throughout the European continent, citing the presence of 19 species (MARTINEZ, 2004) with host-plants known by only 3 species (BENAVENT-CORAI *et al.*, 2005): *Pseudonapomyza atra* (Meigen, 1830) (mining on *Apera*, *Avena*, *Holcus*, *Hordeum*, *Lolium*, *Phalaris*, *Poa*, *Secale* and *Triticum*); *P. balcanensis* Spencer, 1973; *P. errata* Zlobin 1993; *P. europaea* Spencer 1973; *P. hispanica* Spencer, 1973 (*Sorghum*); *P. hobokensis* Scheirs, 1996; *P. hungarica* Spencer, 1973; *P. insularis* Zlobin, 1993; *P. lacteipennis* (Malloch, 1913); *P. mohelnica* Cerny, 1992; *P. moraviae* Cerny, 1992; *P. odessae* Cerny, 1998; *P. palavae* Cerny, 1998; *P. palliditarsis* Cerny, 1992; *P. spenceri* Cerny, 1992; *P. spicata* (Malloch, 1914) (*Saccharum*, *Triticum* and *Zea*); *P. spinosa* Spencer, 1973 (*Brachiaria*, *Eleusine*, *Hordeum* and *Triticum*); *P. strobliana* Spencer, 1973; and *P. vota* Spencer, 1973. Those species represent 43.2% of the known species at Palaearctic level (44 species). A total of 92 worldwide species are known to be spread in the most regions except in South America (ZLOBIN, 2002a). The predominant worldwide *Pseudonapomyza* distribution is Afrotropical, Oriental and Australian (CERNY, 1992).

The morphological diagnosis characteristics of the genus *Pseudonapomyza* are summarized by DEMPEWOLF (2004): the wing costa is extending only to generate R_{4+5}, and the 2nd costal section is conspicuously short less than 1.5 times length of 4th (SPENCER, 1986). The 2nd cross vein is missing, and the 3rd antennal segment is angulate (only for species feeding on Poaceae). The mesonotum and the abdominal tergites often present a bluish shine. It has the epandrium long, the surstyli fused, and the hypandrium rather short with a broad frame. The aedeagal apodeme is often long. The tip of aedeagus is at most strongly pigmented, with well visible appendages of distiphallus. The larva mandibles normally each have two alternating mouth hooks.

There are one or more rows of conspicuous setae on each segment. The pupation often takes place in the mine but not always.

General information on *Pseudonapomyza atratula*

Pseudonapomyza atratula was discovered in Tunisia and described by ZLOBIN (2002b). Since then it was the only citation that was known of the presence of this species in the world. The typical material (all from Tunisia) studied by Zlobin comes from the Zoological Institute of the Russian Academy of Sciences, St. Petersburg (ZIN) and from the collection of the Zoological Museum of the Lund University, Sweden (ZMLU), without the citation of known host-plants.

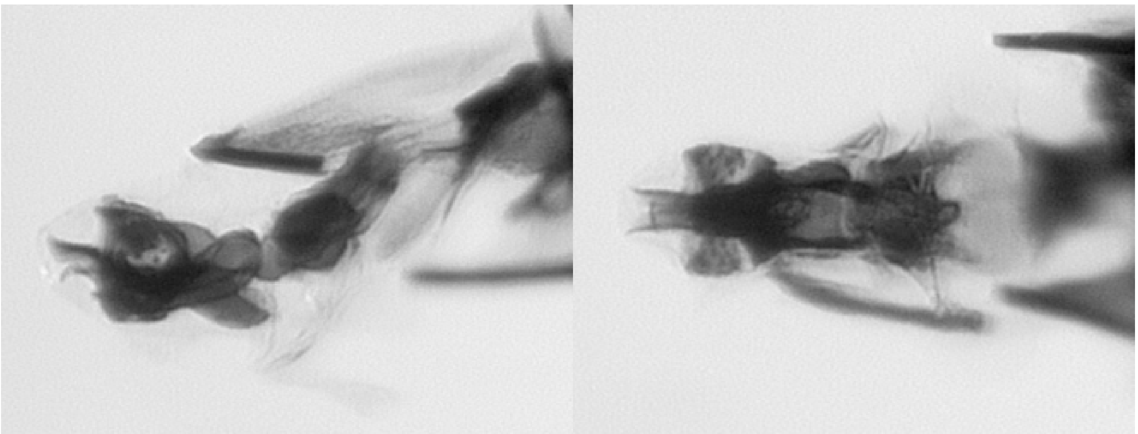

Figure 1. *Pseudonapomyza atra* (Meigen, 1830) aedeagus. Left in lateral view; right in ventral view.

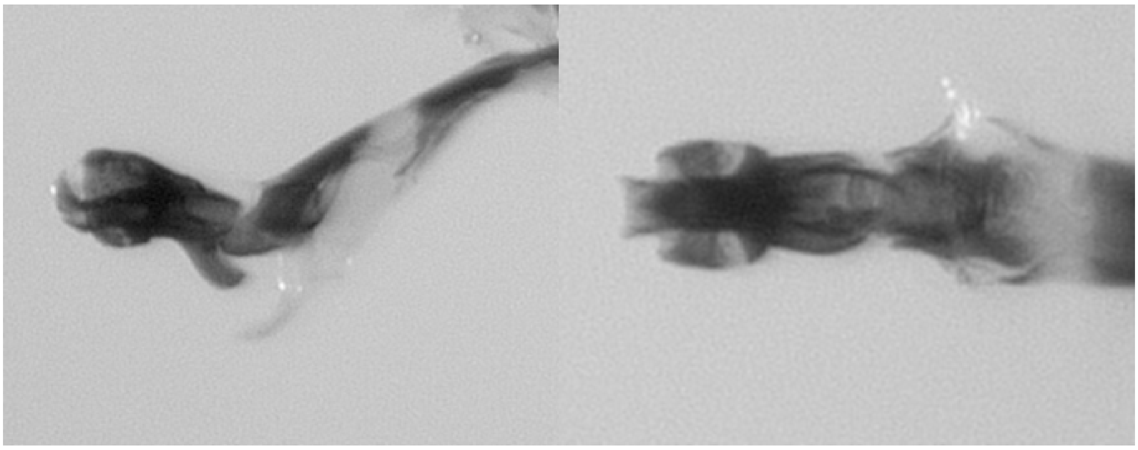

Figure 2. P*seudonapomyza atratula* Zlobin, 2002 aedeagus. Left in lateral view; right in ventral view.

P. atratula is a genus belonging to the *atra*-group with 72 known species in the world, which are exclusive miners on Poaceae. The close morphological proximity between species makes the specific identification only possible by the genitalia study. In this sense, *P. atratula* is a species close to *P. atra* which differs by some details in the shape of aedeagus (Figs. 1 and 2) and spermathecae. Essentially, the *P. atratula* basiphallus have a central part desclerotized or hyaline. The mesophallus lack a prominent ventral projection typical of *atra*-group. The distiphallus is similar to *P. atra* but the apical sclerite is much slender and ventral projections longer. The ejaculatory apodeme have a long narrow base with a pump entirely membranous. The spermathecae present a subequal size and shape, more or less oval, with truncated base; and the duct at the base is broad (ZLOBIN, 2002b).

The genus *Pseudonapomyza* in Spain

Within Spain the presence of 8 species is reported: *P. atra*, *P. hispanica*, *P. insularis*, *P. lacteipennis*, *P. spinosa*, *P. strobliana*, *P. vota* (MARTÍNEZ & BÁEZ, 2002) and *P. europaea* (CERNY, 2004). Of which only *P. atra* and *P. spinosa* are considered of economic interest (BENAVENT-CORAI *et al.*, 2004).

Studies conducted by our research team in Spain have confirmed the presence of *P. atra* in Pina de Ebro (Zaragoza), in "Tinença de Benifassà" (Castellón) (TN) and in Alfarara (Alicante); *P. spinosa* is also cited in Las Saladas (Teruel) and Porta-coeli (Valencia); *P. hispanica* in Villareal (Castellón) and *P. strobliana* in TN (FRANCÉS, 1994 and ECHEVARRÍA, 1996). Recent studies we have done in the Natural Parks of "Lagunas de la Mata-Torrevieja" (Alicante) (TRV), "Font Roja" (Alicante) (FR), and TN by trapping Malaise have confirmed the presence of those species also adding *P. atratula* (FR, TRV), *P. europeae* (TN), *P. spinosa* (FR, TRV) and *P. vota* (TN, TRV). At least 5 new species have been discovered in Spain during these studies (paper in composition). The lack of work carried out shows few studies of the Agromyzidae family at the level of biodiversity in Spain, being extended to most areas of Europe, North Africa, and Asia (CERNY & MERZ, 2006).

About *Pseudonapomyza atratula* in Spain

Material examined: <u>Lagunas de La Mata-Torrevieja</u>: 3♂, 27.IV.2004-4.V.2004; 5♂, 4-11.V.2004; 1♂, 18-25.V.2004; 1♂, 25.V.2004-1.VI.2006; 2♂, 3.VIII.2004-10.VIII.2004; 1♂, 5-12.X.2004; 1♂, 26.X.2004-2.XI.2004; 1♂, 2-9.XI.2004; 3♂, 9-16.XI.2004; 5♂, 16-23.XI.2004; 7♂, 23-30.XI.2004; 3♂, 30.XI.2004-7.XII.2004; 2♂, 7-14.XII.2004; 8♂, 14-21.XII.2004; 4♂, 21.XII.2004-18.I.2005; 1♂, 18-26.I.2005; 2♂, 8-15.II.2005; 1♂, 22.II.2005-1.III.2005; 1♂, 22-29.III.2005; 3♂, 19-26.IV.2005; 1♂, 26.IV.2005-3.V.2005; 1♂, 31.V.2005-7.VI.2005; 2♂, 27.IX.2005-4.X.2005; 6♂, 4.X.2005-1.XI.2005; 4♂, 1-8.XI.2005; 2♂, 8-15.XI.2005; 2♂, 15-22.XI.2005; 1♂, 22-29.XI.2005; 4♂, 29.XI.2005-6.XII.2005; 1♂, 20-27.XII.2005; 1♂, 27.XII.2005-3.I.2006; 2♂, 3-10.I.2006; 3♂, 24-31.I.2006; 1♂, 14-21.II.2006; 8♂, 28.II.2006-14.III.2006; 8♂, 21-28.III.2006; 5♂, 28.III.2006-4.IV.2006; 1♂, 4-11.IV.2006; 1♂, 11.IV.2006-2.V.2006; 1♂, 16-23.V.2006; 1♂, 24-31.X.2006; 2♂, 7-14.XI.2006; 1♂, 14-21.XI.2006; 8♂, 21-28.XI.2006; 4♂, 28.XI.2006-5.XII.2006; 1♂, 5-12.XII.2006; 3♂, 19-26.XII.2006; 1♂, 26.XII.2006-2.I.2007; 1♂, 2-24.I.2007; 2♂, 6-13.II.2007; 10♂, 20.II.2007-6.III.2007; 8♂, 6-13.III.2007; 3♂, 13-20.III.2007; 5♂, 20-27.III.2007; 1♂, 27.III.2007-3.IV.2007; 1♂, 3-10.IV.2007; 5♂, 17-24.IV.2007; 1♂, 24.IV.2007-1.V.2007; 10♂, 1-8.V.2007; 2♂, 8-16.V.2007. <u>Font Roja</u>: 1♂, 19-26.VI.2006.

Male captures phenology of *Pseudonapomyza atratula* over 3 years of Malaise trapping in "Lagunas de la Mata-Torrevieja" (GPS location N38º01'48.8" / W00º42'00.1" Altitude: 5m) is shown in Fig. 3. There is a significant seasonality of captures with the temperature evolution, different population peaks appear when average temperatures are in a range of about 10-20ºC. Captures occur from late

September/beginning of October continuously to the end of May presenting 8-10 generations annually. The largest captures occur in winter and in spring being estimated around 10 males/week with an average temperature of 15.5-20.5ºC. The particular bioclimatic conditions of the "Lagunas de la Mata-Torrevieja" make most winters mild, and that high average temperatures (>25°C) occur frequently in early May. In the "Font Roja" Natural Park in a parallel Malaise trap (GPS location N38º39'43.1'' / W00º31'04.0'' Altitude: 1076m) study of captures in "Lagunas de La Mata-Torrevieja" a specimen was captured at the end June when average temperatures were 21.2°C.

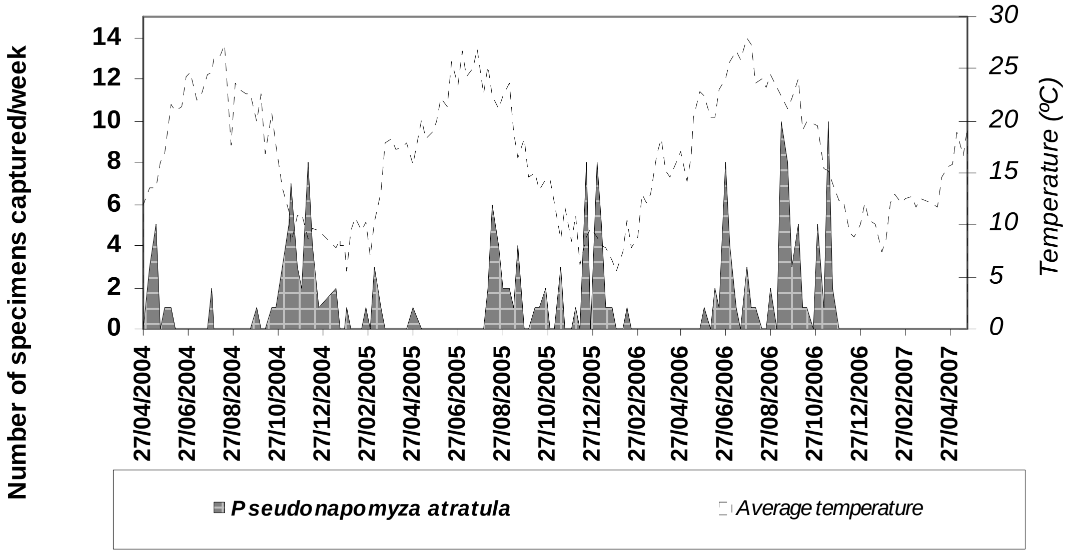

Figure 3. *Pseudonapomyza atratula* Zlobin, 2002 males phenology in "Lagunas de La Mata-Torrevieja" Natural Park.

Subsequent studies should be done to study *P. atratula* females behaviour in the area, tackle only by molecular studies due to the small size of the individuals and the close proximity of morphological species in this genus.

In a parallel study of collecting mined material by our research team in the same location of Malaise traps in the Natural Park of the "Lagunas de la Mata-Torrevieja", we have found host-plants of *P. atratula*. The acquisition of the miners was carried out under controlled conditions of temperature and humidity 25-26ºC, 65-70% RH. The subsequent conservation of specimens in ethyl alcohol 70 made the identification possible by specific morphological study of the genitalia. The material and host-plants of *P. atratula* were *Avena barbata* Pott ex Link: [2♀] sampled (s).30.iv.2007, 1♀ emerged (e).18.v.2007 and 1♀ e.31.v.2007, GPS coordinates of sampling N38º01'35.6"/W00º41'21.1"; and *Avena fatua* L.: [1♂] s.30.iv.2007, e.26.v.2007, GPS coordinates of sampling N38º01'19.7"/W00º40'54.2". Representing the first reports of host-plants attacked by *P. atratula* at worldwide level.

BENAVENT-CORAI *et al.* (2005) cites *Pseudonapomyza atra* as miner in *Avena* genus. The close morphological proximity between *P. atra* and *P. atratula*, suggests that these two species are very near, which is confirmed because both have been found undermining *Avena*. In the same sense, *P. atra* mines other genera such as *Apera*, *Holcus*, *Hordeum*, *Lolium*, *Phalaris*, *Poa*, *Secale* and *Triticum*, which should be considered as potentially susceptible also to *P. atratula*.

Acknowledgements

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5.5 New species for science

5.5.1 New contributions to *Pseudonapomyza* (Diptera: Agromyzidae) from Spain: addition of three new species for science

Abstract. *Pseudonapomyza* (Diptera: Agromyzidae) genus includes the main leaf-miner pests for monocots in Agriculture. Three new species for science collected with Malaise trap in "Tinença de Benifassà", "Font Roja" and "Lagunas de La Mata-Torrevieja" (Spain) Natural Parks are presented: *Pseudonapomyza curvata* n. sp., *Ps. longitata* n. sp. and *Ps. sicicornis* n. sp. Systematics and ecological data are discussed.

Key words. Diptera, Agromyzidae, *Pseudonapomyza*, new species for science, Spain.

Introduction

Pseudonapomyza genus belongs to the subfamily Phytomyzinae within the family Agromyzidae (Diptera). In temperate zones of Northern and Southern hemispheres *Pseudonapomyza* mines exclusively on monocots (SPENCER, 1990).

So far only 8 species have been cited in Spain included within the *Pseudonapomyza* genus: *Pseudonapomyza atra* (Meigen, 1830); *Ps. hispanica* Spencer, 1973; *Ps. insularis* Zlobin, 1993; *Ps. lacteipennis* (Malloch, 1913); *Ps. spinosa* Spencer, 1973; *Ps. strobliana* Spencer, 1973; *Ps. vota* Spencer, 1973 (listed by MARTÍNEZ & BÁEZ, 2002) and *Ps. europaea* Spencer, 1973 (cited by CERNY, 2004). Cereals genera with the most agronomic importance susceptible to be mined by *Pseudonapomyza* genus in Spain are *Avena*, *Secale* and *Triticum* (BENAVENT-CORAI, 2005).

The importance of this genus as pests is cited in some countries of the world such as *Pseudonapomyza asiatica* Spencer (LIAO & SHIAO, 2001) in Taiwan, *Ps. gujaratica* (SHAH, 1982) in India or *Ps. spicata* (Malloch, 1914) in Philippines (LITSINGER & BARRION, 1987). BENAVENT-CORAI (2004) cites as species of economic interest in Spain *Ps. atra* (Meigen, 1830) and *Ps. spinosa* Spencer, 1973. Normally, the low populations of these last species are controlled naturally by parasitoids. The misuse of pesticides and human activities can break this balance or cause the development of pest species that previously were not. Getting to know the overall biodiversity of Agromyzidae is a preventive tool for the present and future pest control.

Material and Methods

Studied areas. (Fig. 1). *Tinença de Benifassà* (Castellón): it is located in the Northern part of Community of Valencia bordering on Tarragona and Teruel provinces. Around 25.8 hectares is the surface area of the park, with minimal anthropological impact (<250 residents). It presents high faunistic and vegetal biodiversity including well preserved woodlands of pine and oak, scrubland composed by typical mediterranean vegetation including a high number of endemisms and crop areas. It has typical snowfalls in winter and high temperatures in summer. Annual rainfall is around 450-550 mm.

Font Roja (Alicante): it is located in Alicante province. It is basically a holm oak mountain composed of Tertiary calcareous rocks. The biodiversity of vegetation is high, includes different areas composed of deciduous wood, shady evergreen or holm oak groves, sunny brushwood zones, rock vegetation, rubble vegetation, pine woods and crops. Annual rainfall is around 350-450mm in the Malaise trap zone, with cold winters and high temperatures in summer.

Lagunas de la Mata-Torrevieja (Alicante): it is located in the southern point of the Community of Valencia. It is characterized by saline soils, semiarid climate, annual precipitations lower than 300 mm and high temperatures. There are salt marsh areas, carrizal-juncal zones and scrubland. Fresh vegetation is present until mid-May, later the high temperatures (>35 ºC) destroy practically all annual plants.

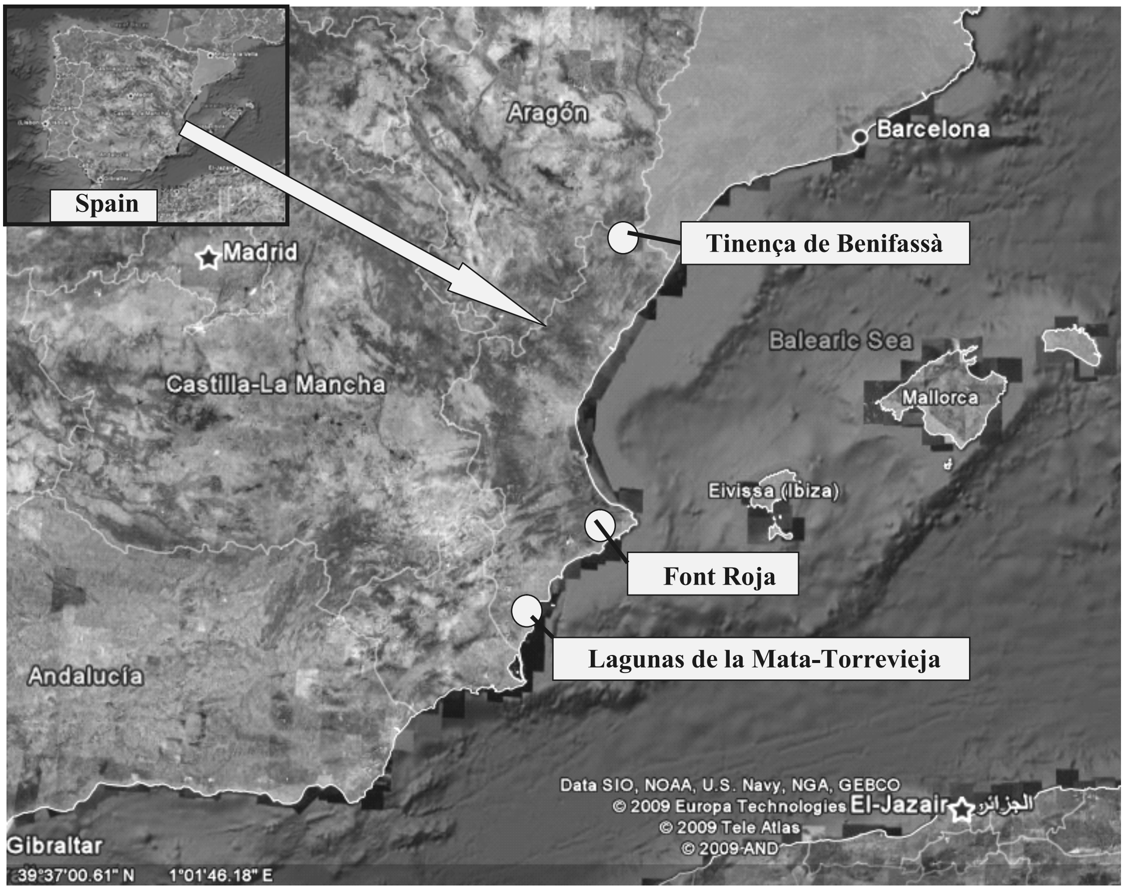


Fig.1. Location of the areas studied in the Community of Valencia (Source: Google earth)

Capture system. Captures were obtained using the Malaise trap capture system (Model G700, Entomopraxis-Barcelona-Spain), demonstrated with broad effectiveness in monitoring the evolution of populations of Agromyzidae flies (von-TSCHIRNHAUS, 1992), throughout the years 2004 to 2006. A GPS system was used to localize the traps (Table 1). Captures were collected weekly, except during periods of snow risk in which the traps were removed. 70 vol. alcohol was used for the specimens conservation.

Code	Natural park	Locality	Altitude	GPS Coordinates	Orography
TN	Tinença de Benifassà	Castellón	755	N40º39'22.6" / E00º09'26.8"	Mountain
FR	Font Roja	Alicante	1076	N38º39'43.1" / W00º31'04.0"	Mountain
TRV	Lagunas de la Mata-Torrevieja	Alicante	5	N38º01'48.8" / W00º42'00.1"	Salt marsh

Table 1. Location parameters of Malaise trap in each of the Natural Parks studied.

Diagnosis. Identifications were carried out with male specimens exclusively, keeping in mind the actual intrinsic difficulty of females' identification. This study uses, mainly, the system of Diptera terminology proposed in the Manual of Nearctic Diptera by McALPINE (1981). On the thorax, the dorsocentral (*dc*) bristles are numbered from posterior to anterior.

Results and discussion

Below are presented three new species for science: *Pseudonapomyza curvata* n. sp., *Ps. longitata* n. sp. and *Ps. sicicornis* n. sp.

Pseudonapomyza curvata n. sp.

Holotype male: Castellón (Spain). *Tinença de Benifassà*: Collected from 20.viii.06 to 28.viii.2006. **Paratypes**: Same locality and position of holotype, 2♂, 1-10.viii.2006; Alicante (Spain). *Font Roja*: 1♂, 24.vi.2004-1.vii.2004; 2♂, 29.vii.2004-2.viii.2004; 1♂, 2-9.viii.2004; 1♂, 9-16.viii.2004; 1♂, 30.viii.2004-6.ix.2004; 1♂, 6-13.ix.2004; 1♂, 4-11.x.2004.

Holotype and paratypes (all males) are deposited in the collection of Cavanilles Institute (Valencia-Spain).

Derivatio nominis. This new species is named according to the particular aedeagus shape.

Description. **Head**. (Fig. 2a). Frons only clearly prominent at level of lunule. 3rd antennal segment pointed, as long as wide, minutely pubescent with short brown pilosity uniformly distributed. Arista normal, with very fine and very short pilosity. Fronto-orbital plate (= parafrontalia) with 2 *ors* (upper orbital) and 3 curved inwards *ori* (lower orbital). Normally, 1 *ors* (lower) inwards directed with a inclination of 45º to the upper part of the head and 1 *ors* (upper) upwards directed slightly inclined to the exterior part of the head are present. Orbital setulae short (9-10) and reclinated. Ocellar triangle 0.12 x 0.11 mm slightly longer than wide, extends to level of *ors*. Two ocellar bristles (*oc*) a little divergent, slightly smaller and as strong as *ors*. Two postocellar bristles (*poc*) clearly divergent and a little longer than *oc*. Internal bristle (*vti*) (= inner vertical setae [*i vt s*] long and strong, much longer than *ors* and *ori*. External vertical bristle (*vte*) (= outer vertical setae [*o vt s*]) strong but a little smaller than *vti* (on average, vti 1.5 times longer than *ors*). Inter-ocular space measured (in frontal view) at level of *ors* = 0.9 X eye (in profile, at a highest measurement). Cheeks forms *arc* below eye. Gena including cheeks (at highest measurement) = 0.28 X eyes (in profile at highest measurement). Eyes without pilosity.

Thorax. Mesonotum with 3+0 long and strong dorsocentral bristles (*dc*) increasing in size to scutellum. *acr* numerous (9-10) irregularly arranged in 5-6 no spaced rows. Intra alar seta (*ia*) small, about same size as *acr*. Anterior and posterior supra alar setae (*spal*) as long and strong as first and second *dc*. Humeral cali with 1 anterior bristle accompanied by 4-5 small setulae. Notopleura with 2 normal notopleural bristles. Posterior part of anapisternum (mesopleura) with 1 strong bristle, and generally 1 small setula at each side. Katapisternum (sternopleura) with 1 strong bristle situated at supero-posterior angle. Disc of scutellum without particular seta except usual 4. 2 apical scutellar setae (*ap sctl s*) generally parallel or very slightly convergent; 2 basal scutellar setae (*b sctl s*) about same size as *ap sctl s*, parallel or slightly directed outwards. Wing: length (on average) 1.05 x 0.63 (long x wide) mm. Thickening of costal (*C*) vein, clearly reaching R_{4+5} ending much before wing tip. Second and third costal section short. In proportion the length from first to fourth costal section is approximately 1:0.63:0.45:0.85. Discal cell (*dm*) and transverse (*dm-cu*) [second cross-vein] missing. Legs: with normal pilosity with the usual pre-apical bristle.

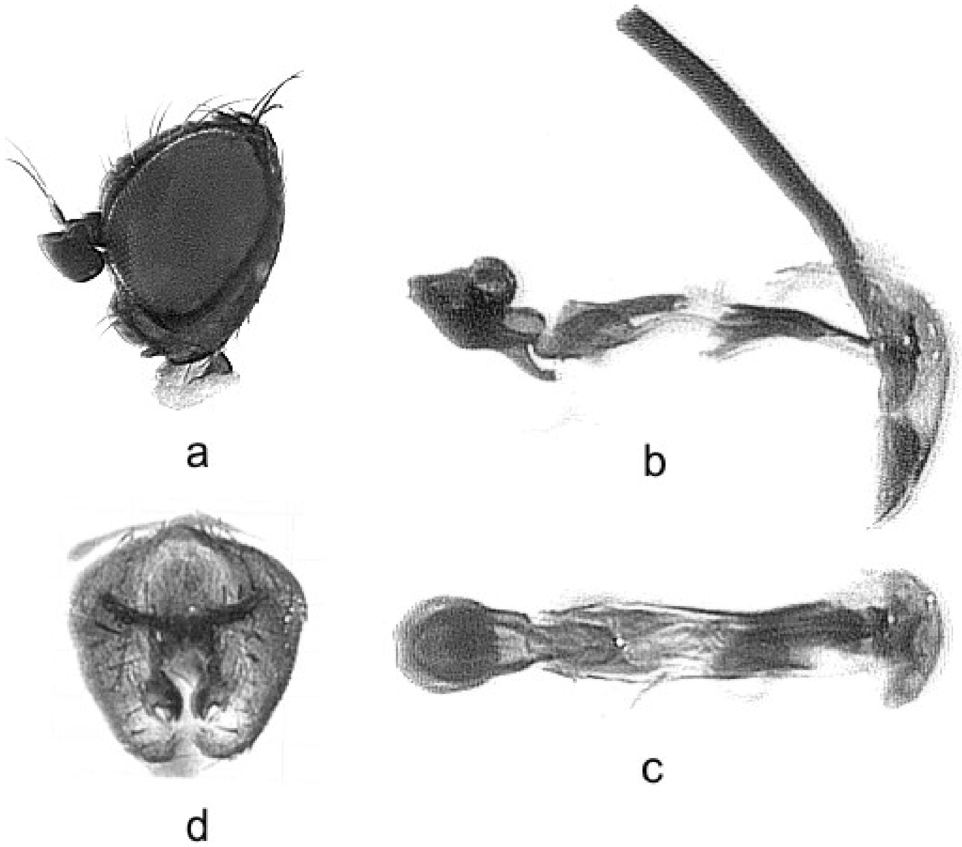


Fig. 2. *Pseudonapomyza curvata* n. sp. Holotype ♂: a- Head in lateral view; b- aedeagus in lateral view; c- aedeagus in ventral view; d- epandrium in anterior view. (Design by R. GIL-ORTIZ).

Abdomen. Setae of the tergites very distinct and relatively numerous arranged stronger on the posterior marginal border.

Coloration. Head entirely brownish, face, front and orbital stripes brown. Lunule light brown. Inner vertical setae (*i vt s* = *vti*) and outer vertical setae (*o vt s* = *vte*) on brown ground. Ocellar triangle dark brown like cheeks. Gena light brown. Torax and scutellum uniformly brown. Mesopleural and sternopleural fringe light brown close to wing. Halter white-transparent. Legs entirely brown. Abdomen brown on the upper side and light brown on the bottom side. Tergites 1 to 5 with a clear darker brown band between contiguous margin, with wide bottom brownish spots.

Aedeagus and associated structures. Aedeagus (Figs. 2b and 2c). Cercus short and thin. Surstylus (=gonostylus) with dense pilosity (12-15 little bristles) inside of each lower corner (Fig. 2d). Sperm pump (=ejaculatory apodeme) longer (0.2 mm) than wide (0.12 mm) (wider part) expanded uniformly on the two sides.

Bionomy. Unknown host-plants.

Phenology. In "Font Roja" this species was found from late June to mid October with average temperatures of 22.4-28.2ºC (36.4ºC max. and 17.1ºC min.) (Fig. 3). In 2004 were produced 3 generations but low captures difficult predict exactly the evolution of this species. Captures of "Tinença de Benifassà" were produced in August with average temperatures of 23.5-24ºC (31ºC max. and 17ºC min.).

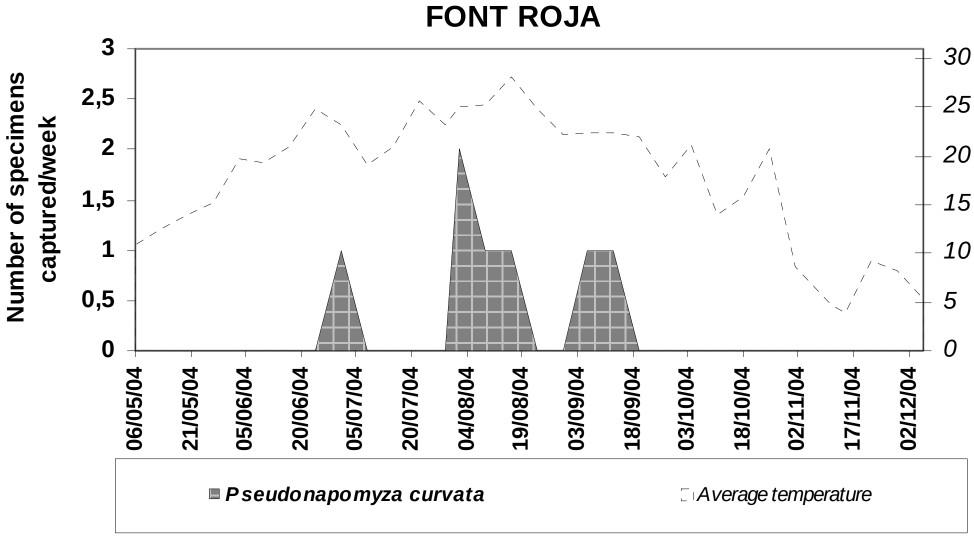


Fig. 3. Space-time evolution of *Pseudonapomyza curvata* n. sp. captures in "Tinença de Benifassà" Natural Park.

Systematic position. This species is well characterized by the particular shape of the aedeagus. In ventral view the distiphallus presents a typical round shape while in lateral view 2 curved structures are present.

Pseudonapomyza longitata n. sp.

Holotype male: Castellón (Spain). *Tinença de Benifassà*: Collected from 6.vi.05 to 13.vi.2005. **Paratypes**: Alicante (Spain). *Font Roja*: 1♂, 17-24.vi.2004; 15♂, 24.vi.2004-1.vii.2004; 6♂, 1-8.vii.2004; 3♂, 15-22.vii.2004; 2♂, 22-29.vii.2004; 7♂, 29.vii.2004-2.viii.2004; 6♂, 2-9.viii.2004; 7♂, 9-16.viii.2004; 6♂, 16-23.viii.2004; 4♂, 23-30.viii.2004; 1♂, 30.viii.2004-6.ix.2004; 1♂, 23-30.v.2005; 1♂, 13-20.vi.2005; 1♂, 27.vi.2005-4.vii.2005; 6♂, 11-18.vii.2005; 1♂, 1-8.viii.2005; 1♂, 15-22.viii.2005; 1♂, 22-29.viii.2005; 1♂, 4-11.v.2006; 1♂, 29.v.2006-5.vi.2006; 1♂, 5-12.vi.2006; 2♂, 12-

19.vi.2006; 9♂, 19-26.vi.2006; 4♂, 26.vi.2006-3.vii.2006; 3♂, 3-10.vii.2006; 1♂, 17-25.vii.2006; 6♂, 25-31.vii.2006; 1♂, 31.vii.2006-7.viii.2006; 3♂, 7-14.viii.2006; 2♂, 14-21.viii.2006; 2♂, 21-28.viii.2006 and 1♂, 4-11.ix.2006. *Lagunas de La Mata-Torrevieja*: 1♂, 9-16.viii.2005; 1♂, 6-13.xii.2005; 1♂, 21-28.iii.2006; 1♂, 31.x.2006-7.xi.2006; 1♂, 20.ii.2007-6.iii.2007; 1♂, 6-13.iii.2007 and 1♂, 13-20.iii.2007.

Holotype and paratypes (all males) are deposited in the collection of Cavanilles Institute (Valencia-Spain).

Derivatio nominis. This new species is named according to the aedeagus shape.

Description. **Head**. (Fig. 4a). Frons moderately prominent between eyes in profile (more pronounced at the height of the lunule). 3rd antennal segment strongly pointed, as long as wide, minutely pubescent with short brown pilosity, these clearly more distinct on the border of the antenna. Arista normal, with very fine and very short pilosity. Fronto-orbital plate (= parafrontalia) with 2 *ors* (upper orbital) and 3 curved inwards *ori* (lower orbital). Normally, 1 *ors* (lower) inwards directed with a inclination of 45º to the upper part of the head and 1 *ors* (upper) upwards directed slightly inclined to the exterior part of the head are present. Orbital setulae short (minimum 12) erected along ori and reclinated along ors in an only row. Ocellar triangle longer than wide (0.13 x 0.11 mm), extends to level of *ors*. Two ocellar bristles (*oc*) slightly divergent or parallel, slightly smaller and as strong as *ors*. Two postocellar bristles (*poc*) slightly divergent and equal or slightly longer than *oc*. Internal bristle (*vti*) (= inner vertical setae [*i vt s*] long and strong, much longer than *ors* and *ori*. External vertical bristle (*vte*) (= outer vertical setae [*o vt s*]) strong but much smaller than *vti* (on average, vti 1.5 times longer than *ors*). Inter-ocular space measured (in frontal view) at level of *ors* = 1.7 X eye (in profile, at a highest measurement). Cheeks forms *arc* below eye. Gena including cheeks (at highest measurement) = 0.32 X eyes (in profile at highest measurement). Eyes without pilosity.

Thorax. Mesonotum with 3+0 long and strong dorsocentral bristles (*dc*) increasing in size to scutellum. *acr* numerous (10-12) irregularly arranged in 8 no spaced rows. Intra alar seta (*ia*) small, about same size as *acr*. Anterior and posterior supra alar setae (*spal*) as long and strong as first and second *dc*. Humeral cali with 1 anterior bristle accompanied by 4-5 small setulae. Notopleura with 2 normal notopleural bristles. Posterior part of anapisternum (mesopleura) with 1 strong bristle, and generally 1 small seta at each side. Katapisternum (sternopleura) with 1 strong bristle situated at supero-posterior angle. Disc of scutellum without particular setula except usual 4. 2 apical scutellar setae (*ap sctl s*) generally parallel or very slightly convergent; 2 basal scutellar setae (*b sctl s*) about same size as *ap sctl s*, directed slightly inwards. Wing: length (on average) 1.4 x 0.6 (long x wide) mm. Thickening of costal (*C*) vein, clearly reaching R_{4+5} ending much before wing tip. Second and third costal section short. In proportion the length from first to fourth costal section is approximately 1:0.7:0.2:0.7. Discal cell (*dm*) and transverse (*dm-cu*) [second cross-vein] missing. Legs: with normal pilosity with the usual pre-apical bristle.

Abdomen. Setae of the tergites very distinct and relatively numerous arranged on dorsal part, while on ventral side fine pilosity is present.

Coloration. Head entirely brownish, face, front and orbital stripes brown. Lunule dark brown. Inner vertical setae (*i vt s* = *vti*) and outer vertical setae (*o vt s* = *vte*) on brown ground. Ocellar triangle dark brown like cheeks. Gena light brown. Torax and scutellum uniformly brown. Mesopleural and sternopleural fringe light brown close to wing. Halter white-transparent. Legs entirely brown. Abdomen brown on the upper side and light brown on the bottom side. Tergites 1 to 5 with a clear darker brown band between contiguous margin, with wide bottom brownish spots.

Aedeagus and associated structures. Aedeagus (Figs. 4b and 4c). Cercus short and thin. Surstylus (=gonostylus) with dense pilosity inside of each lower corner (Figs. 4e and 4f). Sperm pump (=ejaculatory apodeme) longer (0.18 mm) than wide (0.1 mm) (wider part) expanded uniformly on the two sides (Fig. 4d).

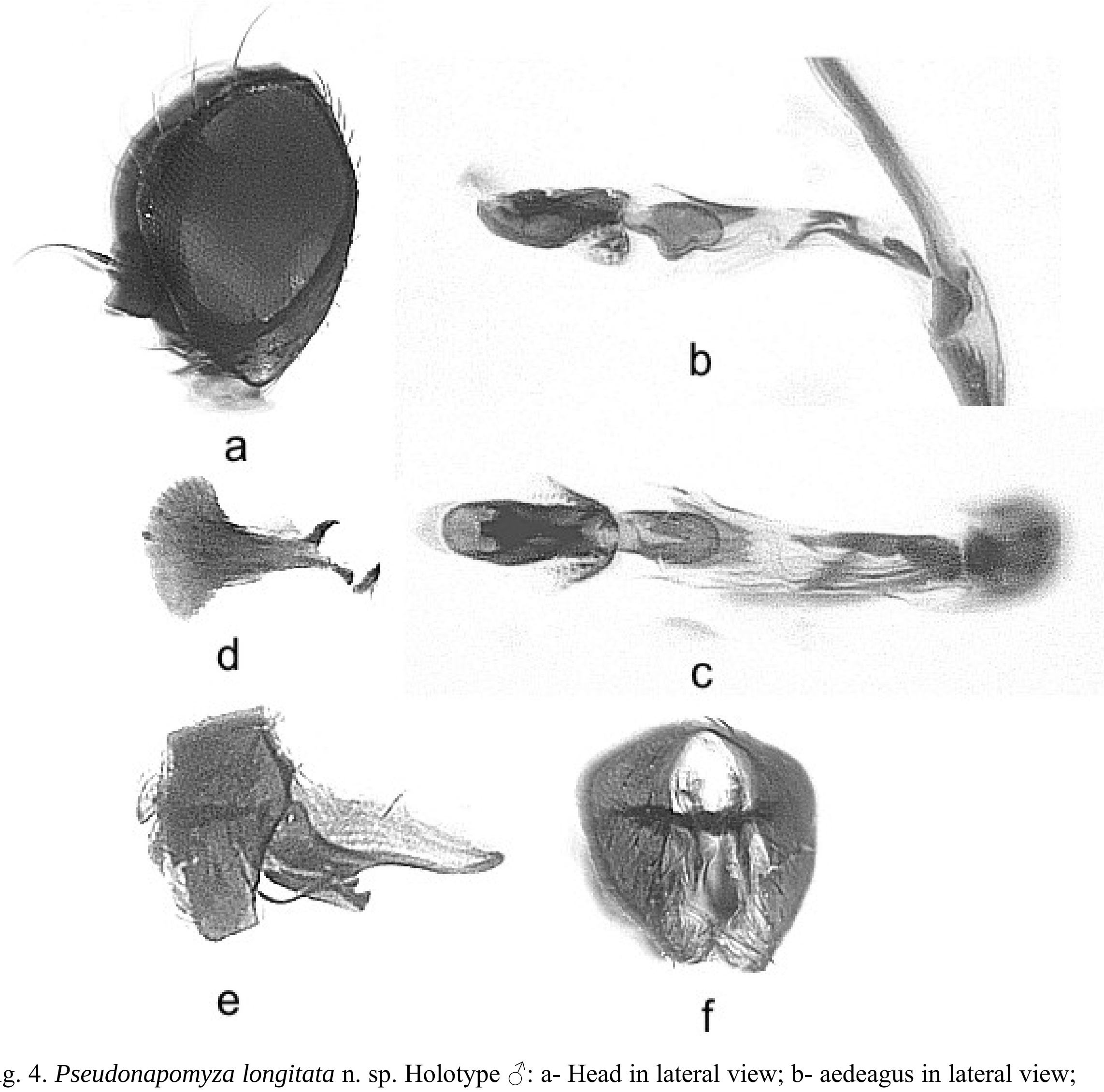


Fig. 4. *Pseudonapomyza longitata* n. sp. Holotype ♂: a- Head in lateral view; b- aedeagus in lateral view; c- aedeagus in ventral view; d- Sperm pump in lateral view; e- epandrium in lateral view; f- epandrium in anterior view. (Design by R. GIL-ORTIZ).

Bionomy. Unknown host-plants.

Phenology. According to the captures produced in "Font Roja", 3-6 generations were distributed from mid-May to mid September (Fig. 5). The biggest captures were 15 males per week produced in late June with an average temperature of 23.2ºC (28.9ºC max. and 17.5ºC min.). The capture in "Tinença de Benifassà" was produced in early/mid June with average temperatures of 19ºC (23ºC max. and 15ºC min.). Captures of this species in "Lagunas de La Mata-Torrevieja" were low and produced irregularly, being in the range of average temperatures of 12.5-27ºC (28ºC max. and 8ºC min.).

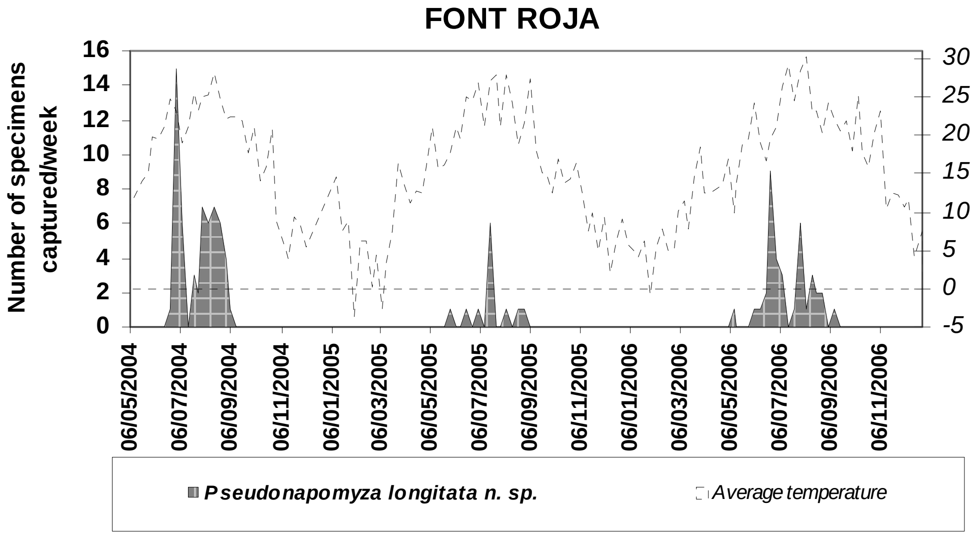


Fig. 5. Space-time evolution of *Pseudonapomyza longitata* n. sp. captures in "Font Roja" Natural Park.

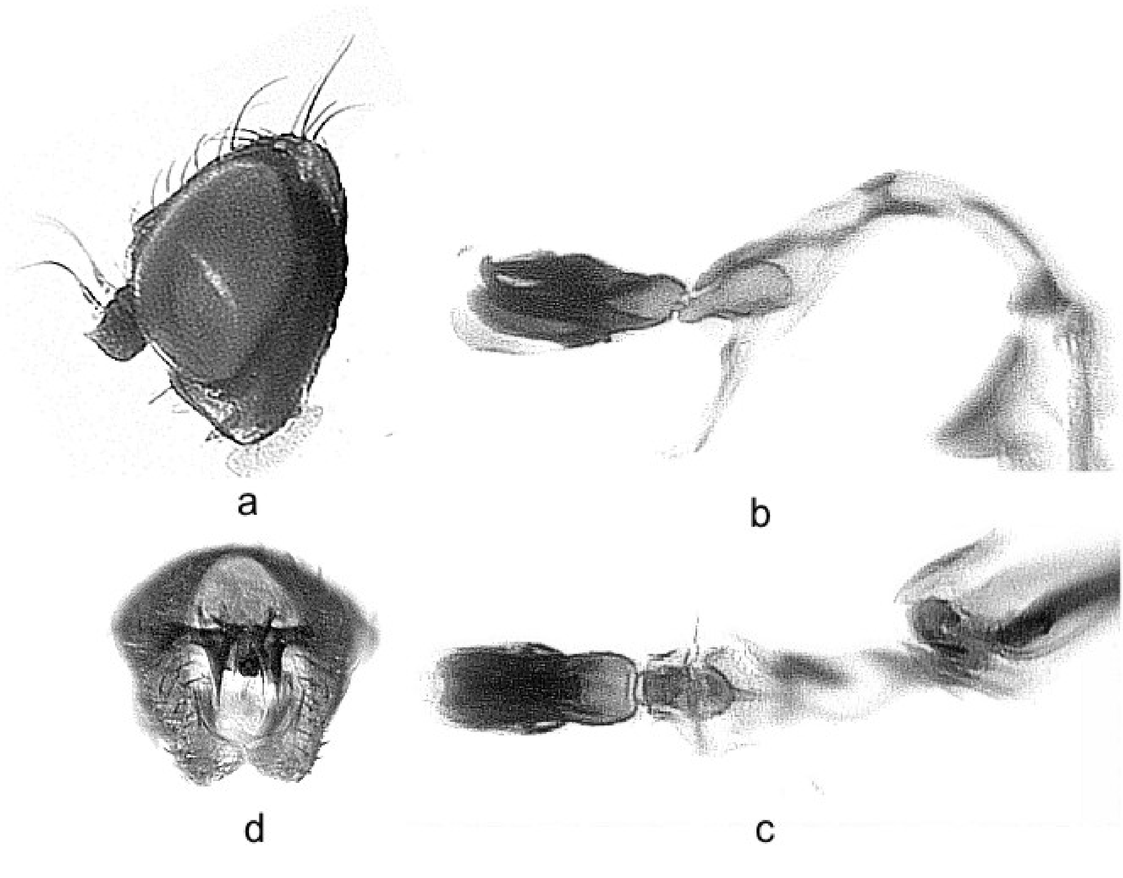
Systematic position. Compared with the rest of the Palaearctic species is observed higher affinity toward *Pseudonapomyza europaea* Spencer, 1963, but it differs in the shape of distiphallus.

Pseudonapomyza sicicornis n. sp.

Holotype male: Spain: Castellón. *Tinença de Benifassà*: Collected from 20.viii.2006 to 28.viii.2006. **Paratype**: neither.

Description. **Head**. (Fig. 6a). Frons only clearly prominent at level of the lunule. 3rd antennal segment strongly pointed, as long as wide, minutely pubescent with short brown pilosity, these clearly more distinct in the body of the antenna. Arista normal, with very fine and very short pilosity. Fronto-orbital plate (= parafrontalia) with 2 *ors* (upper orbital) and 2 curved inwards *ori* (lower orbital). Normally, 1 *ors* (lower) inwards directed with a inclination of 45º to the upper part of the head and 1 *ors* (upper) upwards directed slightly inclined to the exterior part of the head are present. Orbital setulae short slightly reclinated along ori and reclinated along ors in an only row. Ocellar triangle as long as wide (0.1 x 0.1 mm), extends to level of *ors*. Two ocellar bristles (*oc*) slightly divergent or parallel, slightly smaller and as strong as *ors*. Two postocellar bristles (*poc*) slightly divergent and equal or slightly longer than *oc*. Internal bristle (*vti*) (= inner vertical setae [*i vt s*] long and strong, much longer than *ors* and *ori*. External vertical bristle (*vte*) (= outer vertical setae [*o vt s*]) strong but much smaller than *vti* (on average, vti 1.5 times longer than *ors*). Inter-ocular space measured (in frontal view) at level of *ors* = 1.1 X eye (in profile, at a highest measurement). Cheeks forms *arc* below eye. Gena including cheeks (at highest measurement) = 0.25 X eyes (in profile at highest measurement). Eyes without pilosity.

Thorax. Mesonotum with 3+0 long and strong dorsocentral bristles (*dc*) increasing in size to scutellum. *acr* numerous (minimum 10) irregularly arranged in 8-9 no spaced rows. Intra alar seta (*ia*) small, about same size as *acr*. Anterior and posterior supra alar setae (*spal*) as long and strong as first and second *dc*. Humeral cali with 1 anterior bristle accompanied by 4-5 small setulae. Notopleura with 2 normal notopleural bristles. Posterior part of anapisternum (mesopleura) with 1 strong bristle, and generally 1 small setula at each side. Katapisternum (sternopleura) with 1 strong bristle situated at supero-posterior angle. Disc of scutellum without particular seta except usual 4. 2 apical scutellar setae (*ap sctl s*) generally parallel or very slightly convergent; 2 basal scutellar setae (*b sctl s*) about same size as *ap sctl s*, directed slightly inwards. Wing: length (on average) 1.5 x 0.65 (long x wide) mm. Thickening of costal (*C*) vein, clearly reaching R_{4+5} ending much before wing tip. Second and third costal section short. In proportion the length from first to fourth costal section is approximately 1:1:0.4:1. Discal cell (*dm*) and transverse (*dm-cu*) [second cross-vein] missing. Legs: with normal pilosity with the usual pre-apical bristle.



Figs. 6. *Pseudonapomyza sicicornis* n. sp. Holotype ♂: a- Head in lateral view; b- epandrium in anterior view; c- aedeagus in lateral view; d- aedeagus in ventral view. (Design by R. GIL-ORTIZ).

Abdomen. Setae of the tergites very distinct and relatively numerous arranged stronger on the posterior marginal border.

Coloration. Head entirely brownish, face, front and orbital stripes brown. Lunule light brown. Inner vertical setae (*i vt s* = *vti*) and outer vertical setae (*o vt s* = *vte*) on brown ground. Ocellar triangle dark brown like cheeks. Gena light brown. Torax and scutellum uniformly brown. Mesopleural and sternopleural fringe light brown close to wing. Halter white-transparent. Legs entirely brown. Abdomen brown on the upper side and light brown on the bottom side. Tergites 1 to 5 with a clear darker brown band between contiguous margin, with wide bottom brownish spots.

Aedeagus and associated structures. Aedeagus (Figs. 6b and 6c). Cercus short and thin. Surstylus (=gonostylus) with slight pilosity inside of each lower corner (Fig. 6d). Sperm pump (=ejaculatory apodeme) longer (0.22 mm) than wide (0.14 mm) (wider part) expanded uniformly on the two sides.

Bionomy. Unknown host-plants.

Phenology. This species has been captured when average temperatures was 23.5ºC (19ºC min. and 28ºC max.). Based on the captures it is observed an only generation in summer, being difficult to predict the evolution of this species. Although most probably is also present in summer and autumn with several generations.

Notes. This species is characterized by having a particular morphology of the aedeagus. Comparing the aedeagus morphology with the rest of Palaearctic species the species closer is *Pseudonapomyza siciformis* Zlobin, 2002.

Acknowledgements

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5.5.2 Additional *Pseudonapomyza* (Diptera: Agromyzidae) species from Spain

Abstract. New faunistic data included in *Pseudonapomyza* (Diptera: Agromyzidae) genus are presented. Description, ecological aspects of biology and systematic position of *Pseudonapomyza benifassae*, a new species from Spain, are given. In addition a new species is recorded for the first time in Spain: *Ps. palliditarsis* Cerny, 1992. General information about systematic, geographical distribution and phenology are included.

Key words. Diptera, Agromyzidae, *Pseudonapomyza*, new species for science, new record, Spain.

Introduction

Throughout the years 2004-2006 the fly captures of Agromyzidae were carried out with Malaise trap in the Natural Parks of "Tinença de Benifassà" (Castellón-Spain) and "Font Roja" (Alicante). In a previous study of the material, the outcome of a study of male genitalia revealed the presence of a new species for science, *Pseudonapomyza benifassae* n. sp. This species is cited as one of the species found (unpublished data) during the studies carried out by our research team in "Las Saladas" (Teruel), in "Pina del Ebro" (Zaragoza) and also in "Tinença de Benifassà" (Castellón) throughout the years 1991-1994 (ECHEVARRÍA, 1996).

The result of these studies in the "Tinença of Benifassà" Natural Park has also confirmed the presence of a new record in Spain *Pseudonapomyza palliditarsis* Zlobin, 1992. This species was cited by CERNY (1992) in Czechoslovakia and in the former Yugoslavia, which would mean that it should be present in virtually all of Western Europe.

Some of the morphological characters used in the description of species such as the coloration (e.g. squamal fringe, mesonotum, wings and legs) are difficult characters to diagnose when working with material preserved in alcohol due to the loss of pigmentation. This leads to the prevalence of morphometric characters together with the study of the male genitalia as the main factors of diagnosis.

Note : the present study mainly uses the system of Diptera terminology proposed in the Manual of Nearctic Diptera by McALPINE (1981). On the thorax, the dorsocentral (*dc*) bristles are numbered from posterior to anterior.

Pseudonapomyza benifassae n. sp.

Holotype male: Castellón (Spain). *Tinença de Benifassà*: Collected from 16.v.05 to 23.v.2005. **Paratypes**: Same locality and position of holotype, 1♂, 29.vii.2004-5.viii-2004; 1♂, 18-28.vii.2005; 1♂, 29.v.2006-5.vi.2006; 1♂, 3-10.vii.2006 and 3♂, 24.vii.2006-1.viii.2006. Alicante (Spain). *Font Roja*: 1♂, 11-18.vii.2005.

Holotype and paratypes (all males) are deposited in the collection of Cavanilles Institute (Valencia-Spain).

Derivatio nominis. This species is named according to the name of the main locality ("Tinença de Benifassà") where it was captured.

Description. **Head**. (Fig. 1a). Frons slightly prominent between eyes in profile (more pronounced at the height of the lunule). 3rd antennal segment strongly pointed, as long as wide, minutely pubescent with short brown pilosity, these clearly more distinct in the body of the antenna. Arista normal, with very fine and very short pilosity. Fronto-orbital plate (= parafrontalia) with 2 *ors* (upper orbital) and 3 curved inwards *ori* (lower orbital). Normally, 1 *ors* (lower) inwards directed with a inclination of 45º to the upper part of the head and 1 *ors* (upper) upwards directed slightly inclined to the exterior part of the head are present. Orbital setulae short erected along ori and reclinated along ors in an only row. Ocellar triangle slightly longer than wide (0.12 x 0.11 mm), extends to level of *ors*. Two ocellar bristles (*oc*) slightly divergent or parallel, a little smaller and as strong as *ors*. Two postocellar bristles (*poc*) slightly divergent and equal or slightly longer than *oc*. Internal bristle (*vti*) (= inner vertical setae [*i vt s*] long and strong, much longer than *ors* and *ori*. External vertical bristle (*vte*) (= outer vertical setae [*o vt s*]) strong but much smaller than *vti* (on average, vti 1.5 times longer than *ors*). Inter-ocular space measured (in frontal view) at level of *ors* = 1.1 X eye (in profile, at a highest measurement). Cheeks forms *arc* below eye. Gena including cheeks (at highest measurement) = 0.32 X eyes (in profile at highest measurement). Eyes without pilosity.

Thorax. Mesonotum with 3+0 long and strong dorsocentral bristles (*dc*) increasing in size to scutellum. *acr* numerous (12) regularly arranged in 6-7 spaced rows. Intra alar seta (*ia*) small, about same size as *acr*. Anterior and posterior supra alar setae (*spal*) as long and strong as first and second *dc*. Humeral cali with 1 anterior bristle accompanied by 4-5 small setulae. Notopleura with 2 normal notopleural bristles. Posterior part of anapisternum (mesopleura) with 1 strong bristle, and generally 1 small setula at each side. Katapisternum (sternopleura) with 1 strong bristle situated at supero-posterior angle. Disc of scutellum without particular seta except usual 4. 2 apical scutellar setae (*ap sctl s*) generally parallel or very slightly convergent; 2 basal scutellar setae (*b sctl s*) about same size as *ap sctl s*, directed slightly inwards. Wing: length (on average) 0.75 x 0.34 (long x wide) mm. Thickening of costal (*C*) vein, clearly reaching R_{4+5} ending much before wing tip. Second and third costal section short. In proportion the length from first to fourth costal section is approximately 1:1:0.4:1. Discal cell (*dm*) and transverse (*dm-cu*) [second cross-vein] missing. Legs: with normal pilosity with the usual pre-apical bristle.

Abdomen. Setae of the tergites very distinct and relatively numerous arranged uniformly.

Coloration. Head entirely brownish, face, front and orbital stripes brown. Lunule dark brown. Inner vertical setae (*i vt s = vti*) and outer vertical setae (*o vt s = vte*) on brown ground. Ocellar triangle dark brown like cheeks. Gena light brown. Torax and scutellum uniformly brown. Mesopleural and sternopleural fringe light brown close to wing. Halter white-transparent. Legs entirely brown. Abdomen brown on the upper side and light brown on the bottom side. Tergites 1 to 5 with a clear darker brown band between contiguous margin, with wide bottom brownish spots.

Aedeagus and associated structures. Aedeagus (Figs. 1b and 1c). Cercus short and thin. Surstylus (=gonostylus) with short uniform pilosity inside of each lower corner (Figs. 1e and 1f). Sperm pump (=ejaculatory apodeme) longer (0.2 mm) than wide (0.11 mm) (wider part) expanded uniformly on the two sides (Fig. 1d).

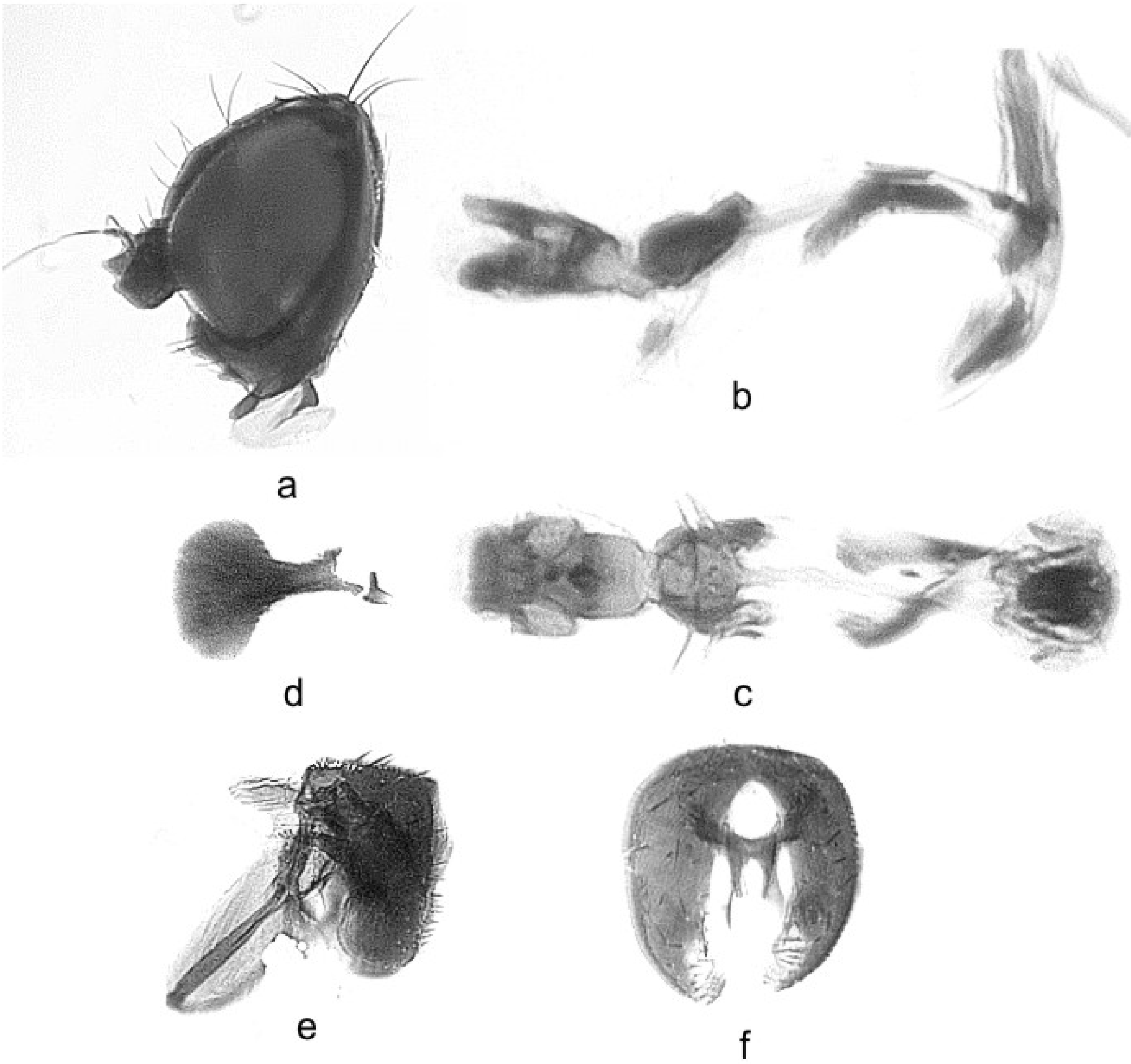

Fig. 1. *Pseudonapomyza benifassae* n. sp. Holotype ♂: a- Head in lateral view; b- aedeagus in lateral view; c- aedeagus in ventral view; d- Sperm pump in lateral view; e- epandrium in lateral view; f- epandrium in anterior view. (Design by R. GIL-ORTIZ).

Bionomy. ECHEVARRÍA (1996) cites this species as sleeving on *Brachypodium* sp. (Poaceae) and *Tamarix canariensis* L. (Tamaricaceae), being the only references from the host-plants of this species. *Tamarix* must be excluded as the host genus of this species but it is certain that this new *Pseudonapomyza* developed on Poaceae, possibly on *Brachypodium*.

Phenology. In "Tinença Benifassà" this species is present from mid May to September (ECHEVARRÍA, 1996) with average temperatures of 17-27ºC (32ºC max. and 10ºC min.) (Fig. 2). The captures in "Font Roja" took place in mid July with average temperatures of 27ºC (31.9 ºC max. and 21 ºC min.).

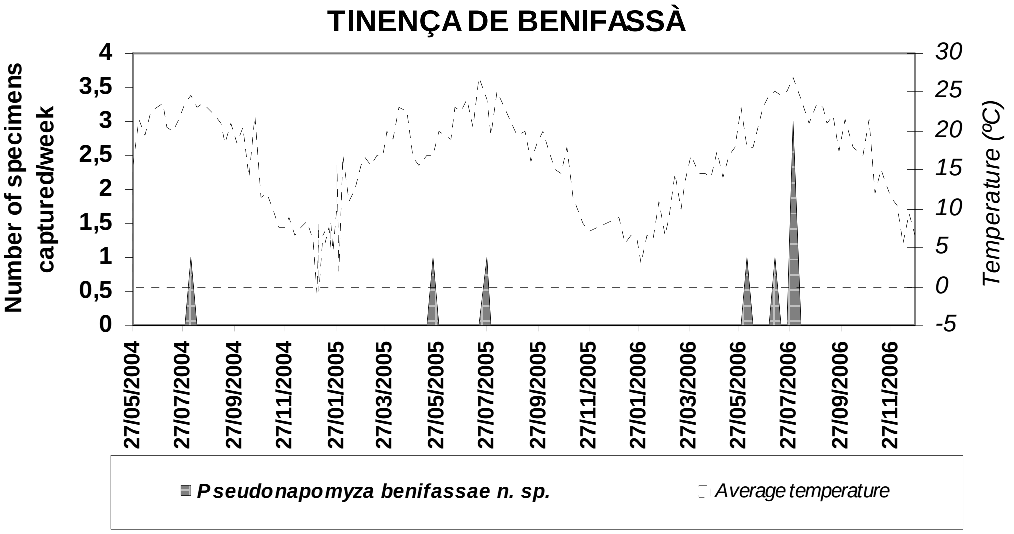

Fig. 2. Space-time evolution of *Pseudonapomyza benifassae* n. sp. captures in "Tinença de Benifassà" Natural Park.

Systematic position. This species is well characterized by its particular shape of the aedeagus. In its ventral view an elongated distiphallus is present and is narrower in its anterior half. The mesophallus is bladder shaped with two lateral extensions more schlerotized. A side view of the distiphallus shows a characteristic opening.

Pseudonapomyza palliditarsis **Cerny, 1992** (First record for Spain)

Material examined: Tinença de Benifassà: 1♂, 12-19.ix.2005 and 1♂, 1-10.viii.2006.

Description. **Head**. (Fig. 3a). Frons slightly prominent between eyes in profile (more pronounced at the height of the lunule). 3rd antennal segment strongly pointed, as long as wide, minutely pubescent with short brown pilosity, these clearly more distinct on the border of the antenna. Arista normal, with very fine, and very short pilosity. Fronto-orbital plate (= parafrontalia) with 1 *ors* (upper orbital) slightly upwards directed and inclined to the exterior part of the head and 3 curved inwards *ori* (lower orbital). Orbital setulae short (minimum 12) erected along *ori* and reclinated along *ors* in an only row. Ocellar triangle as long as wide (0.1 x 0.1 mm), extends to level of *ors*. Two ocellar bristles (*oc*) slightly divergent or parallel, slightly smaller and as strong as *ors*. Two postocellar bristles (*poc*) slightly divergent and equal or slightly longer than *oc*. Internal bristle (*vti*) (= inner vertical setae [*i vt s*] long and strong, much longer than *ors* and *ori*. External vertical bristle (*vte*) (= outer vertical setae [*o vt s*]) strong but much smaller than *vti* (on average, vti 1.5 times longer than *ors*). Inter-ocular space measured (in frontal view) at level of *ors* = 1.4 X eye (in profile, at a highest measurement). Cheeks forms *arc* below eye. Gena including cheeks (at highest measurement) = 0.45 X eyes (in profile at highest measurement). Eyes without pilosity.

Thorax. Mesonotum with 3 long and strong dorsocentral bristles (*dc*) incresing in size to scutellum. *acr* numerous (minimum 12) irregularly arranged in 6 no spaced rows.

Intra alar seta (*ia*) small, about same size as *acr*. Anterior and posterior supra alar setae (*spal*) as long and strong as first and second *dc*. Humeral cali with 1 anterior bristle accompanied by 4-5 small setulae. Notopleura with 2 normal notopleural bristles. Posterior part of anapisternum (mesopleura) with 1 strong bristle, and generally 1 small setula at each side. Katapisternum (sternopleura) with 1 strong bristle situated at supero-posterior angle. Disc of scutellum without particular setula except usual 4. 2 apical scutellar setulae (*ap sctl s*) generally parallel or very slightly convergent; 2 basal scutellar setulae (*b sctl s*) about same size as *ap sctl s*, directed slightly inwards. Wing: length (on average) 1.4 x 0.6 (long x wide) mm. Thickening of costal (*C*) vein, clearly reaching R_{4+5} ending much before wing tip. Second and third costal section short. In proportion the length from first to fourth costal section is approximately 1:0.8:0.5:0.7. Discal cell (*dm*) and transverse (*dm-cu*) [second cross-vein] missing. Legs: with normal pilosity with the usual pre-apical bristle.

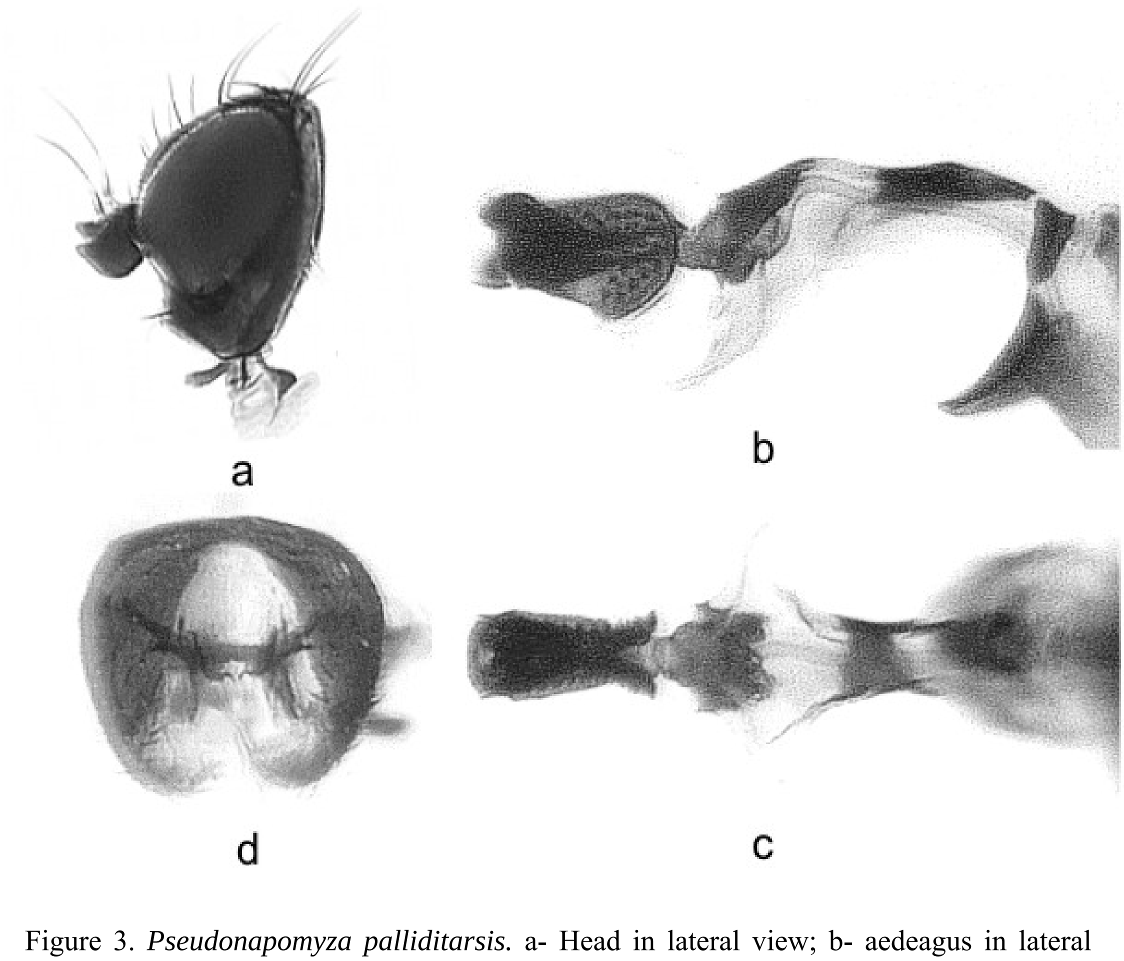

Figure 3. *Pseudonapomyza palliditarsis.* a- Head in lateral view; b- aedeagus in lateral view; c- aedeagus in ventral view; d- epandrium in anterior view. (Design by R. GIL-ORTIZ).

Abdomen. Setae of the tergites very distinct and relatively numerous arranged on dorsal part, while on ventral side fine pilosity is present.

Coloration. Entirely brownish head, face, front and orbital stripes brown. Lunule dark brown. Inner vertical setae (*i vt s* = *vti*) and outer vertical setae (*o vt s* = *vte*) on brown ground. Ocellar triangle dark brown like cheeks. Gena light brown. Torax and scutellum uniformly brown. Mesopleural and sternopleural fringe light brown close to wing. Halter white-transparent. Legs entirely brown. Abdomen brown on the upper side and light brown on the bottom side. Tergites 1 to 5 with a clear darker brown band between contiguous margin, with wide bottom brownish spots.

Aedeagus and associated structures. Aedeagus (Figs. 3b and 3c). Cercus short and thin. Surstylus (=gonostylus) with dense pilosity inside of each lower corner (Fig. 3d). Sperm pump (=ejaculatory apodeme) is longer (0.2 mm) than wide (0.11 mm) (wider part) expanded uniformly on both sides.

Distribution. Czechoslovakia, Spain, former Yugoslavia.

Bionomy. Unknown host-plants.

Phenology. This species has been captured when average temperatures were 20ºC (11ºC min. and 31ºC max.). Based on the captures a generation in summer and another in autumn is observed, that are probably composed of several generations beginning in spring and ending in late autumn.

Acknowledgements

This manuscript has been supported by the Ministry of Education and Science of the Spanish government and by European Regional Development Fund (ERDF) (project CGL2004-02711) CGL2004-02711 directed by Dr. Ricardo Jiménez Peydró.

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5.5.3 *Pseudonapomyza mediterranea* n. sp. (Diptera: Agromyzidae) from salt marshes in Spain

Abstract. Description, ecological aspects of biology and systematic position of *Pseudonapomyza mediterranea*, a new species from Spain ("Lagunas de la Mata-Torrevieja" Natural Park) are given.

Key words. Diptera, Agromyzidae, *Pseudonapomyza*, new species for science, Spain.

Introduction

Pseudonapomyza Hendel, 1920 is one of genera with the largest morphological uniformity within the Agromyzidae family (CERNY, 1998). This is the reason why in the early twentieth century the only study of the external morphology decreased the discovery of the new species. The great difficulty of obtaining miners from their host-plants (monocotyledons plants in temperate areas) (SPENCER, 1990) makes the study of *Pseudonapomyza* from their host-plants slowed down even more.

SPENCER (1973) and subsequently CERNY (1992) began the study of the morphology of the male genitalia within the *Pseudonapomyza* genus. 99 valid species are known worldwide, among these 44 are present in the Palaearctic region. In Spain the only presence of 8 species are cited, which informs us of the enormous lack of knowledge of this genus (extensible to most genera of Agromyzidae) in Spain: *Pseudonapomyza atra* (Meigen, 1830); *Ps. hispanica* Spencer, 1973; *Ps. insularis* Zlobin, 1993; *Ps. lacteipennis* (Malloch, 1913); *Ps. spinosa* Spencer, 1973; *Ps. strobliana* Spencer, 1973; *Ps. vota* Spencer, 1973 (listed by MARTÍNEZ & BÁEZ, 2002) and *Ps. europaea* Spencer, 1973 (cited by CERNY, 2004).

Throughout 2004-2007 fly captures of Agromyzidae with Malaise trap was carried out in the Natural Park of "Las Lagunas de La Mata-Torrevieja" (Alicante-Spain). In a previous study of the material, the outcome of a study of the male genitalia revealed the presence of a new species for science, *Pseudonapomyza mediterranea* n. sp. This species is cited as one of the species found (unpublished data) during the studies carried out by our research team in "Las Saladas" (Teruel) and "Pina de Ebro" (Zaragoza) throughout the years 1991-1992 (ECHEVARRÍA, 1996). The main common characteristic between the habitats in which they have found this species is that they are salt marsh environments.

Some of the morphological characters used in the description of species such as the coloration (e.g. squamal fringe, mesonotum, wings and legs) are difficult characteristics of diagnosis when working with material preserved in alcohol due to the loss of pigmentation. Therefore, the main diagnostic factors used for the specific characterization came from the morphological study of the male genitalia.

Note : this study uses, mainly, the system of Diptera terminology proposed in the Manual of Nearctic Diptera by McALPINE (1981). On the thorax, the dorsocentral (*dc*) bristles are numbered from posterior to anterior.

Pseudonapomyza mediterranea n. sp.

Holotype male: Spain: Alicante. Lagunas de La Mata-Alicante Natural Park. Collected with Malaise trap from 3.v.05 to 10.v.2005. GPS location: N38º39'43.1'' W00º31'04.0''. **Allotype**: neither. **Paratypes**: Same locality and position of holotype, 1♂, 16-23.v.2006; 2♂, 19.ix.2006; 17.x.2006 and 1♂, 24-31.x.2006.

Holotype and paratypes (all males) are deposited in the collection of Cavanilles Institute (Valencia-Spain).

Derivatio nominis. This new species is named in accordance with the geographical area where it was found.

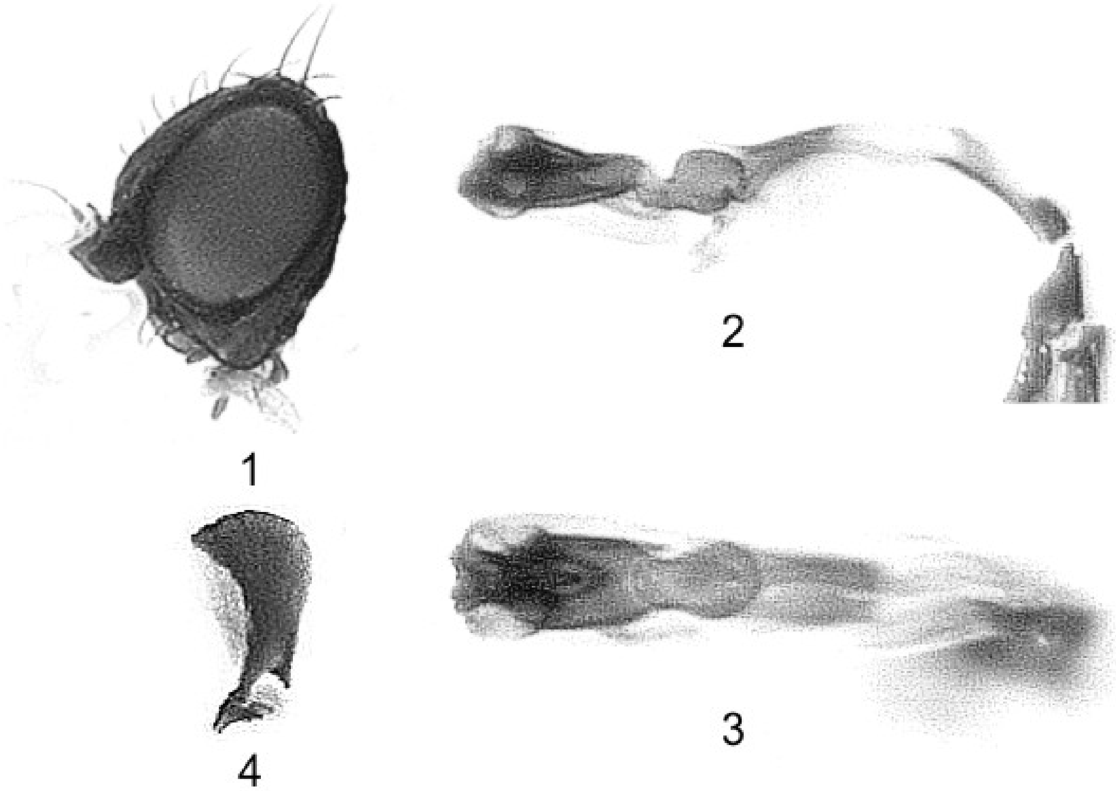
Description. **Head** (Fig. 1). Frons clearly prominent between eyes in profile (more pronounced at the height of the lunule). 3rd antennal segment strongly pointed, as long as wide, minutely pubescent with short brown pilosity, these clearly more distinct in the body of the antenna. Arista normal, with very fine and very short pilosity. Fronto-orbital plate (= parafrontalia) with 2 *ors* (upper orbital) and 3 *ori* (lower orbital). Normally, 1 *ors* (lower) inwards directed with a inclination of 45º to the upper part of the head and 1 *ors* (upper) upwards directed slightly inclined to the exterior part of the head are present. Orbital setulae short (minimum 12) erected along *ori* and reclined along *ors* in a single row. Ocellar triangle slightly longer than wide, extends to level of upper *ors*. Two ocellar bristles (*oc*) slightly divergent or parallel, slightly smaller and as strong as *ors*. Internal bristle (*vti*) (= inner vertical setae [*i vt s*]) long and strong, much longer than *ors* and *ori* (on average, *vti* 1.5 times longer than *ors*). External vertical bristle (*vte*) (= outer vertical setae [*o vt s*]) strong but much smaller than *vti*. Inter-ocular space measured (in frontal view) at level of *ors* = 1.5 X eye (in profile, at a highest measurement). Cheeks forms arc below eye. Gena including cheeks (at highest measurement) = 0.45 to 0.48 X eyes (in profile at highest measurement). Eyes without pilosity.

Thorax. Mesonotum with 3+0 long and strong dorsocentral bristles (*dc*) increasing in size to scutellum. *acr* numerous irregularly arranged in 10 rows. Intra alar seta (*ia*) small, about same size as *acr*. Anterior and posterior supra alar setae (*spal*) as long and strong as first and second *dc*. Humeral cali with 1 anterior bristle accompanied by 5 (sometimes 6) small setulae. Notopleura with 2 normal bristles. Posterior part of anapisternum (mesopleura) with 1 strong bristle, and generally 1 small setae at each side. Katapisternum (sternopleura) with 1 strong bristle situated at supero-posterior angle. Scutellum with the usual 4 setae: 2 apical scutellar setae (*ap sctl s*) generally parallel or very slightly convergent; 2 basal scutellar setae (*b sctl s*) about same size as *ap sctl s*, directed slightly inwards. Wing: length (on average) 1.5 x 0.65 (long x wide) mm. Thickening of costal (*C*) vein clearly reaching R_{4+5}. Second and third costal section short. In proportion the length from first to fourth costal section is approximately 1:0.64:0.4:0.69. Discal cell (*dm*) and transverse (*dm-cu*) [second cross-vein] missing. Legs: with normal pilosity with the usual pre-apical bristle.

Abdomen. Setae of the tergites very distinct and relatively numerous arranged stronger on the posterior marginal border.

Coloration. Head entirely brownish, front, parafrontalia and orbital stripes brown. Face and lunule brown, palpi brown. Inner vertical setae (*i vt s* = *vti*) and outer vertical setae (*o vt s* = *vte*) on brown ground. Only ocellar triangle dark brown like cheeks. Gena light brown. Thorax and scutellum uniformly brown. Calypteral fringe light brown close to wing. Halter white-transparent. Legs entirely brown but tarsi light brown. Abdomen brown on the dorsal side and paler on the ventral side. Tergites 1 to 5 with a clear darker brown band between contiguous margin, with wide bottom brownish spots.

Aedeagus and associated structures. Aedeagus as in Figs. 2 and 3. Cercus short and thin. Gonostylus (= surstylus) with dense pilosity inside of each lower corner. Sperm pump (= ejaculatory apodeme) longer (0.2 mm) than wide (0.11 mm) (wider part), curved only sideways (Fig. 4).



Figs. 1-3. *Pseudonapomyza mediterranea* n. sp. Holotype ♂: 1- Head in lateral view; 2- aedeagus in lateral view; 3- the same in ventral view; 4. Sperm pump in lateral view. (Design by R. GIL-ORTIZ)

Bionomy. Probably the normal host-plants of this species belong to Poaceae. In this area we have confirmed the presence of other *Pseudonapomyza* species mining on Poaceae, the normal host-family of this genus in temperate areas.

Phenology (Fig. 5). The low captures make the phenology of this species difficult to predict, considering the main reason for the low captures is the little host-plants presence in the placement area of the Malaise trap. However, it appears that there are 2 main generations, one in spring and another in autumn. Spring captures were obtained in May with average temperatures of 22.5-26.2ºC (19ºC min. and 29.5ºC max.), while autumn captures were produced from late September to late October with average temperatures of 23-23.5ºC (15ºC min. and 32ºC max.). The fact that this species supports the high daytime temperatures (>30°C) suggests that this species is also present during the months of June and July.

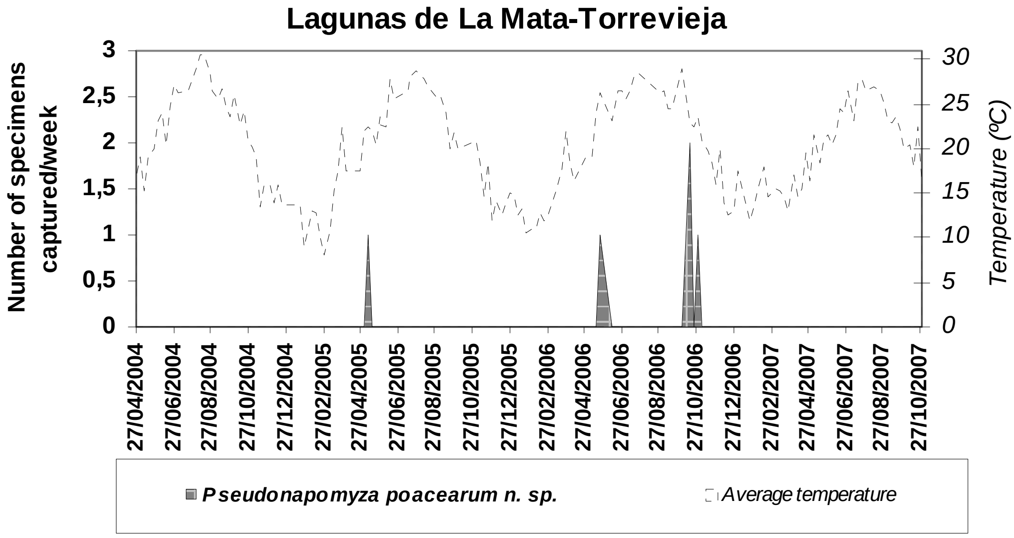


Fig. 4. Space-time evolution of *Pseudonapomyza mediterranea* n. sp. captures in "Lagunas de La Mata-Torrevieja" Natural Park.

Systematic position. This new species is near *Pseudonapomyza spicata* (Malloch, 1914). This last species has been found undermining the genus *Panicum*, *Saccharum*, *Triticum* and *Zea* (Spencer, 1990). The fundamental difference between these two species is the shape of distiphallus which is shorter and wider in the case of *Ps. spicata*.

Acknowledgements

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5.5.4 Inventory of other new species for science

All new species cited are deposited in the collection of the Instituto Cavanilles (Valencia) in default of their systematic characterization and publication. We have considered their mention in this thesis for the only purposes of analytical study of biodiversity. Anyway, I consider that with absolute certainty that further studies of biodiversity of Diptera in Valencia will reveal the existence of additional species new to science. The close proximity between morphological species means that often there are cryptic species hardly detected by morphological differences that require to be confirmed by molecular biology techniques.

Subfamily *Agromyzinae*

Genus ***Agromyza*** Fallén, 1810

Agromyza n. sp. 1

Material examined: Tinença de Benifassà: 1♂, 15-22.v.2006; 1♂, 22-29.v.2006; 1♂, 12-19.vi.2006.

Host-plants: unknown.

Phenology: present in spring with average temperatures of 18-23ºC (23-30ºC max. and 13-16ºC min.).

Agromyza n. sp. 2

Material examined: Tinença de Benifassà: 1♂, 12-19.ix.2005; 1♂, 3-10.x.2005; 1♂, 18-26.ix.2006; 1♂, 25.ix.2006-2.x.2006; 6♂, 2-12.x.2006; Lagunas de La Mata-Torrevieja: 5♂, 16-23.xi.2004; 5♂, 23-30.xi.2004; 2♂, 30.xi.2004-7.xii.2004; 3♂, 7-14.xii.2004; 48♂, 14-21.xii.2004; 91♂, 21.xii.2004-18.i.2005; 22♂, 18-26.i.2005; 9♂, 26.i.2005-2.ii.2005; 5♂, 2-8.ii.2005; 10♂, 8-15.ii.2005; 2♂, 22.ii.2005-1.iii.2005; 2♂, 1-8.iii.2005; 4♂, 22-29.iii.2005; 1♂, 29.iii.2005-5.iv.2005; 1♂, 4.x.2005-1.xi.2005; 5♂, 15-22.xi.2005; 4♂, 22-29.xi.2005; 7♂, 29.xi.2005-6.xii.2005; 12♂, 6-13.xii.2005; 4♂, 13-20.xii.2005; 4♂, 20-27.xii.2005; 3♂, 27.xii.2005-3.i.2006; 2♂, 3-10.i.2006; 2♂, 10-17.i.2006; 1♂, 17-24.i.2006; 3♂, 24-31.i.2006; 6♂, 31.i.2006-7.ii.2006; 3♂, 7-14.ii.2006; 1♂, 14-21.ii.2006; 14♂, 21-28.ii.2006; 1♂, 28.ii.2006-14.iii.2006; 1♂, 2-9.v.2006; 1♂, 7-14.xi.2006; 1♂, 14-21.xi.2006; 5♂, 21-28.xi.2006; 6♂, 28.xi.2006-5.xii.2006; 4♂, 5-12.xii.2006; 4♂, 12-19.xii.2006; 4♂, 19-26.xii.2006; 4♂, 26.xii.2006-2.i.2007; 1♂, 2-24.i.2007; 1♂, 27.iii.2007-3.iv.2007; 1♂, 17-24.iv.2007.

Host-plants: unknown.

Phenology: in "Tinença de Benifassà" it has been only captured basically in autumn. Maximum captures were obtained with average temperatures of 23ºC (18ºC max. and 13ºC min.). In "Lagunas de La Mata-Torrevieja" Natural Park greater captures were produced in 2004/2005 with 3-4 generations distributed from mid November to early April (Fig. 1). Maximum captures were of 91 males/week with average temperatures of 13.8ºC (23ºC max. and 7.5ºC min.).

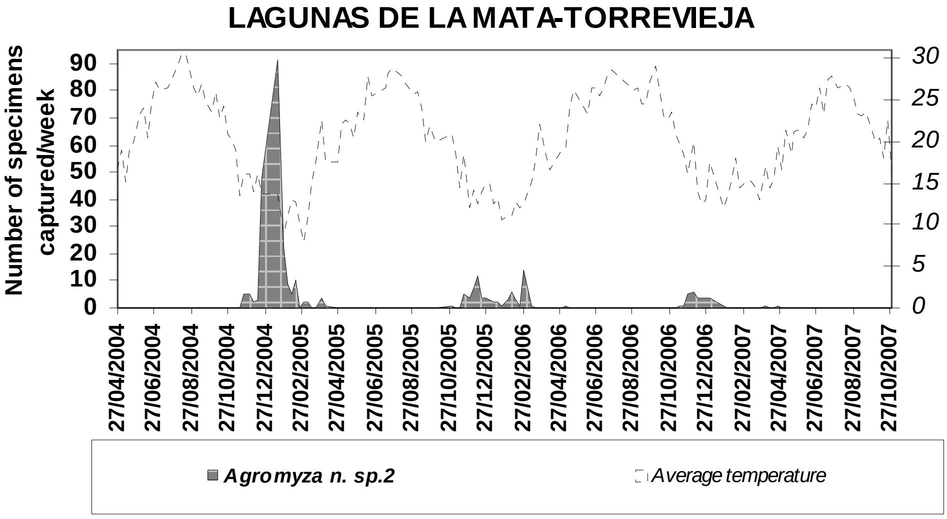

Figure 1. Space-time captures evolution of *Agromyza* n. sp. 2 males in Natural Park of "Lagunas de La Mata-Torrevieja".

Agromyza n. sp. 3

Material examined: Lagunas de La Mata-Torrevieja: 1♂, 23-30.xi.2004; 1♂, 7-14.xii.2004; 1♂, 15-22.xi.2005.

Host-plants: unknown.

Phenology: captures were produced in autumn with average temperatures of 16-18.5ºC (18-22ºC max. and 14-15ºC min.).

Genus ***Ophiomyia*** Bražnikov 1897

Ophiomyia n. sp. 1

Material examined: Tinença de Benifassà: 1♂, 1-8.vii.2004; 1♂, 22-29.v.2006; 1♂, 5-12.vi.2006; Font Roja: 1♂, 22-29.vii.2004; 1♂, 2-9.viii.2004; 1♂, 26.vi.2004-3.vii.2004; 1♂, 17-25.vii.2004.

Host-plants: unknown.

Phenology: "Tinença de Benifassà" captures were produced from last spring to beginning summer with average temperatures of 18-23ºC (25-30ºC max. and 11-16ºC min.). In "Font Roja" captures were also very low and produced in summer with average temperatures of 23.3-28.4ºC (28.2-35.4ºC max. and 17.1-21.4ºC min.).

Ophiomyia n. sp. 2

Material examined: Tinença de Benifassà: 1♂, 1-8.viii.2005; 1♂, 19-26.vi.2006; Font Roja: 2♂, 3-10.vi.2004; 1♂, 22-29.vii.2004; 1♂, 29.vii.2004-2.viii.2004; 1♂, 9-16.viii.2004; 1♂, 15-23.v.2005; 1♂, 15-22.v.2006; 1♂, 19-26.vi.2006; 2♂, 17-25.vii.2006; 1♂, 7-14.viii.2006; 2♂, 11-18.ix.2006.

Host-plants: unknown.

Phenology: present in "Tinença de Benifassà" in summer with average temperatures of 23-25ºC (29-32ºC max. and 17-18ºC min.). In Font Roja captures were also present in spring and autumn with average temperatures of 19.4-29.2ºC (28.2-36.4ºC max. and 12.5-20ºC min.).

Ophiomyia n. sp. 3

Material examined: Tinença de Benifassà: 1♂, 26.vi.2006-3.vii.2006.

Host-plants: unknown.

Phenology: the male captured was obtained in summer with average temperatures of 24.5ºC (33ºC max. and 16ºC min.).

Ophiomyia n. sp. 4

Material examined: Tinença de Benifassà: 1♂, 11-18.vii.2005; 1♂, 26.vi.2006-3.vii.2006; 2♂, 10-17.vii.2006.

Host-plants: unknown.

Phenology: captures were produced in "Tinença de Benifassà" in summer with average temperatures of 24.5-27ºC (31-33ºC max. and 16-22ºC min.).

Ophiomyia n. sp. 5

Material examined: Font Roja: 1♂, 15-22.v.2006.

Host-plants: unknown.

Phenology: the male captured was obtained spring with average temperatures of 19.4ºC (24ºC max. and 14.7ºC min.).

Ophiomyia n. sp. 6

Material examined: Tinença de Benifassà: 1♂, 22-29.v.2006; 1♂, 5-12.vi.2006; 2♂, 12-19.vi.2006.

Host-plants: unknown.

Phenology: captures obtained were very small and produced in early summer with average temperatures between 16.6-24.2ºC (21.3-32.4ºC max. and 11.8-16ºC).

Subfamily *Phytomyzinae*

Genus ***Cerodontha*** Rondani, 1961

Cerodontha (Poemyza) **n. sp. 1**

Material examined: Tinença de Benifassà: 1♂, 15-22.v.2006; 1♂, 22-29.v.2006.

Host-plants: unknown.

Phenology: two male were captured in mid-spring with average temperatures of 18-23ºC (23-30ºC max. and 13-16ºC min.).

Genus ***Liriomyza*** Mik 1894

Liriomyza **n. sp. 1**

Material examined: Tinença de Benifassà: 1♂, 2-12.x.2006.

Host-plants: unknown.

Phenology: present in “Tinença de Benifassà” in mid October with average temperatures of 18ºC (23ºC max. and 13ºC min.).

Liriomyza **n. sp. 2**

Material examined: Font Roja: 1♂, 14-21.viii.2006; 1♂, 21-28.viii.2006.

Host-plants: unknown.

Phenology: present in mid-summer in “Font Roja” with average temperatures of 20.3-24.3ºC (27.1-32.9ºC max. and 13.5-15.7ºC min.).

Liriomyza **n. sp. 3**

Material examined: Lagunas de La Mata-Torrevieja: 1♂, 4-11.v.2004; 1♂, 18-26.i.2005; 1♂, 22.ii.2005-1.iii.2005; 1♂, 1-8.xi.2005; 1♂, 28.iii.2006-4.iv.2006; 1♂, 26.xii.2006-2.i.2007.

Host-plants: unknown.

Phenology: present from autumn to spring with moderate temperatures. Captures were produced with average temperatures of 8-17.5ºC (10-24.5ºC max. and 5.5-16ºC min.) (Fig. 1).

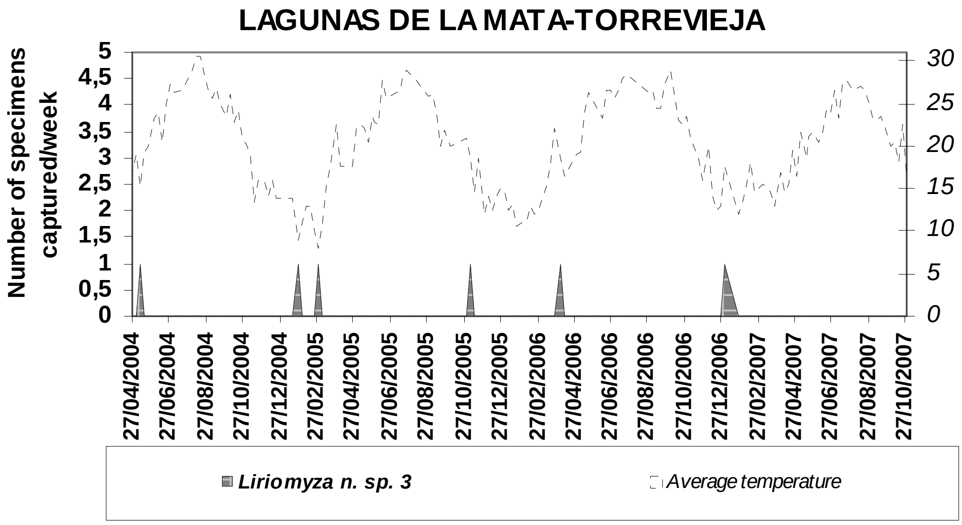

Figure 1. Space-time captures evolution of *Agromyza* n. sp. 2 males in Natural Park of "Lagunas de La Mata-Torrevieja".

Liriomyza n. sp. 4

Material examined: <u>Lagunas de La Mata-Torrevieja</u>: 1♂, 12-19.ix.2006.

Host-plants: unknown.

Phenology: the male captured was obtained autumn with average temperatures of 24.5ºC (28ºC max. and 21ºC min.).

Genus ***Metopomyza*** Enderlein 1936

Metopomyza n. sp. 1

Material examined: <u>Tinença de Benifassà</u>: 1♂, 16-23.v.2005.

Host-plants: unknown.

Phenology: the only capture was captured in "Tinença de Benifassà" in spring with average temperatures of 17ºC (22ºC max. and 12ºC min.).

Genus ***Phytomyza*** Fallén, 1810

Phytomyza n. sp. 1

Material examined: <u>Tinença de Benifassà</u>: 1♂, 20-27.v.2004.

Host-plants: unknown.

Phenology: the only capture was obtained in “Tinença de Benifassà” in spring with average temperatures of 17ºC (22ºC max. and 12ºC min.).

Phytomyza n. sp. 2

Material examined: Tinença de Benifassà: 1♂, 21-28.x.2004; 1♂, 16-23.v.2005.

Host-plants: unknown.

Phenology: captures were produced in both mid-spring and mid-autumn with average temperatures of 11.5-17ºC (14-22ºC max. and 9-12ºC min.).

Phytomyza n. sp. 3

Material examined: Tinença de Benifassà: 1♂, 6-17.iv.2006.

Host-plants: unknown.

Phenology: the only capture was obtained in “Tinença de Benifassà” in spring with average temperatures of 14.5ºC (19ºC max. and 10ºC min.).

Phytomyza n. sp. 4

Material examined: Tinença de Benifassà: 1♂, 22-29.v.2006; 2♂, 29.v.2006-5.vi.2006; 1♂, 12-19.vi.2006.

Host-plants: unknown.

Phenology: captures were produced in “Tinença de Benifassà” in spring with average temperatures of 18-23ºC (26-30ºC max. and 10-16ºC min.).

Phytomyza n. sp. 5

Material examined: Tinença de Benifassà: 2♂, 20-27.vi.2005; 1♂, 27.vi.2005-4.vii.2005.

Host-plants: unknown.

Phenology: captures were produced in “Tinença de Benifassà” at the beginning of summer with average temperatures of 22.5-24ºC (29-31ºC max. and 16-17ºC min.).

Genus ***Pseudonapomyza*** Hendel, 1920

Pseudonapomyza sp. 1

Material examined: Tinença de Benifassà: 1♂, 23-30.v.2005; 1♂, 11-18.vii.2005.

Host-plants: unknown.

Phenology: This species has been captured when average temperatures ranges 20-27ºC (15ºC min. and 32ºC max.). Based on the captures it is observed at least two generations between spring and summer, that probably will last until autumn.

Note: This species is characterized by having an abnormally low pointed antenna and the frons strongly prominent between the eyes in profile. The structure of the aedeagus is like any Palaearctic species characterized by its short length and rounded shape.

Pseudonapomyza sp. 2

Material examined: Tinença de Benifassà: 1♂, 6-13.vi.05; 1♂, 16-23.v.2005; 2♂, 23-30.v.2005; 7♂, 6-13.vi.2005; 3♂, 29.v.2006-5.vi.2006; 4♂, 5-12.vi.2006; 4♂, 19-26.vi.2006 and 1♂, 25.ix.2006-2.x.2006; Lagunas de La Mata-Torrevieja: 1♂, 27.iv.2004-4.v.2004.

Host-plants: unknown.

Phenology: This species has been captured when average temperatures ranges 17-23ºC (29ºC min. and 10ºC max.). Based on the captures the presence of this species is at least from mid-May to last June and also present in mid-Autumn.

Note: This species is characterized by the shape of the aedeagus very close to *Ps. atra*. Possibly is a cryptic species into *atra-group* but molecular biology have to confirm.

Pseudonapomyza sp. 3

Material examined: Font Roja: 1♂, 10-17.vi.2004; 3♂, 24.vi.04-1.vii.2004; 4♂, 1-8.vii.2004; 4♂, 8-15.vii.2004; 3♂, 15-22.vii.2004; 6♂, 22-29.vii.2004; 1♂, 29.vii.2004-2.viii.2004; 10♂, 2-9.viii.2004; 8♂, 9-16.viii.2004; 2♂, 16-23.viii.2004; 1♂, 23-30.viii.2004; 1♂, 6-13.ix.2004; 1♂, 15-23.v.2005; 3♂, 27.vi.2005-4.vii.2005; 1♂, 4-11.vii.2005; 1♂, 18-25.vii.2005; 1♂, 22-29.viii.2005; 4♂, 29.viii.2005-5.ix.2005; 3♂, 19-23.vi.2006; 3♂, 26.vi.2006-3.vii.2006; 1♂, 3-10.vii.2006; 2♂, 10-17.vii.2006; 3♂, 17-25.vii.2006; 5♂, 25-31.vii.2006; 1♂, 31.vii.2006-7.viii.2006; 3♂, 7-14.viii.2006; 2♂, 14-21.viii.2006; 4♂, 21-28.viii.2006 and 1♂, 4-11.ix.2006.

Host-plants: unknown.

Phenology: this species is present in “Font Roja” from last spring to mid-autumn with 4-5 generations annually. Maximum captures were produced with average temperatures of 25.3ºC (33.5ºC max. and 17.1ºC min.).

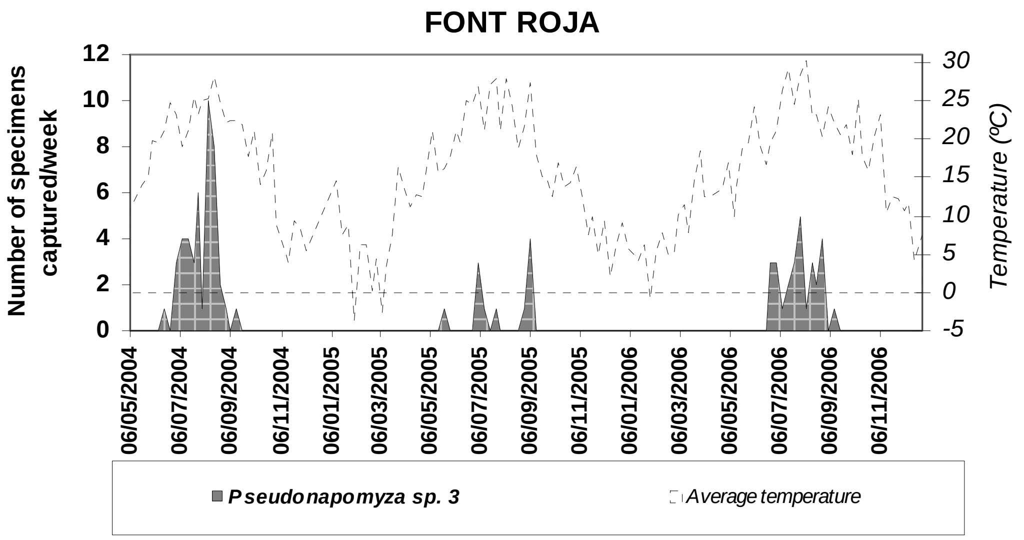

Figure 1. Space-time captures evolution of *Pseudonapomyza* n. sp. 2 males in Natural Park of "Lagunas de La Mata-Torrevieja".

Note: the aedeagus study have revealed a particular structure very close to *Pseudonapomyza europaea* Spencer, 1973. We have to confirm if really it is a new species, meanwhile we consider this species at level of morph species waiting for to confirm this status.

Pseudonapomyza sp. 4

Material examined: Font Roja: 1♂, 4-11.x.2004.

Host-plants: unknown.

Phenology: the only capture was obtained in "Font Roja" in spring with average temperatures of 14ºC (19ºC max. and 9ºC min.).

Note: this specimen have a particular shape of the aedeagus that difficult to estimate its identification. We expect to have more specimens and reconsider its status, meanwhile we less at level of morph species.

5.6 α, β and γ biodiversity study

A tool for the ecological studies of habitats is their biodiversity analysis. The biodiversity alpha (α), beta (β) and gamma (γ) is studied below for each of the Natural Parks studied.

The number of species from a specified number of individuals or biomass (KEMPTON, 1979) is an extremely useful measure of biodiversity. In our case the sample sizes are determined by the diversity and effectiveness of the Malaise trap used. So although the sample sizes are different, the representativeness of the sample is maintained because it is used the same capture system during the same period of time for each of the Natural Parks studied.

Measures of species richness provide a comprehensive and instantaneous expression of diversity. Species richness like a measure of diversity were used successfully in many studies such as those of ABBOTT (1974), CONNOR & SIMBERLOFF (1978) and HARRIS (1984) (MAGURRAN, 1988). Table 5-5 shows the total breakdown of species captured for each Natural Park. An overall total of 114 species is found. The Natural Park of “Tinença de Benifassà” showed the higher species richness with 89, followed by 38 species in “Font Roja” and 37 in “Lagunas de La Mata-Torrevieja”. The presence of 25 new records for Spain and 26 new species for science are indicated.

TOTAL NUMBER OF AGROMYZIDAE SPECIES			
SUBFAMILY AGROMYZINAE	Tinença de Benifassà	Font Roja	***Lagunas de La Mata-Torrevieja***
Agromyza abiens Zetterstedt, 1848	**4**	-	-
***Agromyza anthracina* Meigen, 1830**	-	-	**9**
Agromyza apfelbecki Strobl, 1902	**7**	-	**2**
***Agromyza bromi* Spencer, 1966**	**65**	-	-
Agromyza conjuncta Spencer, 1966	**4**	-	**65**
Agromyza frontella (Rondani, 1875)	**3**	**1**	-
Agromyza graminicola Hendel, 1931	-	-	**1**
***Agromyza hiemalis* Becker, 1908**	-	**1**	-
Agromyza intermittens (Becker, 1907)	**-**	**-**	**53**
Agromyza johannae de Meijere, 1924	-	**1**	-
***Agromyza megalopsis* Hering, 1933**	-	-	**7**
Agromyza nana Meigen, 1830	**10**	-	**1**
Agromyza nigrescens Hendel, 1920	**14**	-	-
Agromyza rondensis Strobl, 1900	**2**	-	**101**
***Agromyza* n. sp. 1**	**3**	-	-

Agromyza **n. sp. 2**	**10**	**-**	**315**
Agromyza **n. sp. 3**	**-**	**-**	**3**
Melanagromyza albocilia Hendel, 1931	**64**	**-**	**-**
Melanagromyza eupatorii **Spencer, 1957**	**3**	**-**	**-**
Melanagromyza fabae Spencer, 1973	**1**	**-**	**-**
Melanagromyza nibletti **Spencer, 1957**	**6**	**-**	**-**
Melanagromyza sojae **Zehnter, 1900**	**1**	**-**	**-**
Melanagromyza spinulosa **Spencer, 1974**	**15**	**-**	**-**
Melanagromyza **n. sp. 1**	**1**	**-**	**-**
Melanagromyza verbasci Spencer, 1957	**5**	**-**	**-**
Ophiomyia beckeri (Hendel, 1923)	**131**	**49**	**47**
Ophiomyia labiatarum Hering, 1937	**25**	**1**	**-**
Ophiomyia ononidis Spencer, 1966	**28**	**2**	**9**
Ophiomyia orbiculata (Hendel, 1931)	**12**	**-**	**-**
Ophiomyia penicillata **Hendel, 1920**	**1**	**1**	**-**
Ophiomyia vitiosa Spencer, 1964	**15**	**-**	**-**
Ophiomyia **n. sp. 1**	**2**	**13**	**-**
Ophiomyia **n. sp. 2**	**3**	**4**	**-**
Ophiomyia **n. sp. 3**	**1**	**-**	**-**
Ophiomyia **n. sp. 4**	**4**	**-**	**-**
Ophiomyia **n. sp. 5**	**-**	**1**	**-**
Ophiomyia **n. sp. 6**	**4**	**-**	**-**
AGROMYZINAE RICHNESS	**29**	**10**	**12**
SUBFAMILY PHYTOMYZINAE	Tinença de Benifassà	Font Roja	***Lagunas de La Mata-Torrevieja***
Amauromyza (Amauromyza) morionella (Zetterstedt, 1848)	**-**	**1**	**-**
Amauromyza (Cephalomyza) karli (Hendel, 1927)	**9**	**-**	**-**
Amauromyza (Cephalomyza) monfalconensis (Strobl, 1909)	**1**	**-**	**-**
Aulagromyza buhri **(de Meijere, 1938)**	**4**	**-**	**-**
Aulagromyza luteoscutellata **(de Meijere, 1924)**	**1**	**-**	**67**
Aulagromyza orphana (Hendel, 1920)	**50**	**-**	**-**
Aulagromyza similis **(Brischke, 1880)**	**1**	**-**	**-**
Aulagromyza trivittata **(Loew, 1873)**	**36**	**-**	**67**
Calycomyza humeralis (von Roser, 1840)	**7**	**-**	**4**

Cerodontha (Cerodontha) denticornis (Panzer, 1806)	**12**	**2**	**27**
Cerodontha (Dizigomyza) crassiseta (Strobl, 1900)	**1**	**1**	-
***Cerodontha (Poemyza) lapplandica* (Rydén, 1956)**	**2**	-	-
Cerodontha (Poemyza) lateralis (Macquart, 1835)	**1**	-	-
Cerodontha (Poemyza) muscina (Meigen, 1830)	**1**	-	-
***Cerodontha (Poemyza)* n. sp. 1**	**3**	-	-
Chromatomyia horticola (Goureau, 1851)	**18**	**1**	-
Chromatomyia succisae (Hering, 1922)	**15**	**1**	-
***Liriomyza amoena* (Meigen, 1830)**	**1**	-	-
Liriomyza brassicae (Riley, 1884)	**281**	**3**	**7**
Liriomyza bryoniae (Kaltenbach, 1858)	**111**	-	**3**
Liriomyza cicerina (Rondani, 1875)	-	-	**8**
Liriomyza congesta (Becker, 1903)	**11**	**1**	**3**
***Liriomyza erucifolii* de Meijere, 1944**	**20**	-	-
Liriomyza eupatorii (Kaltenbach, 1873)	**5**	-	-
Liriomyza flaveola (Fallén, 1823)	**1**	**1**	-
***Liriomyza graminivora* Hering, 1949**	**2**	-	-
Liriomyza orbona (Meigen, 1830)	**27**	**1**	**133**
Liriomyza pusilla (Meigen, 1830)	**5**	-	-
***Liriomyza samogitica* Pakalniškis, 1996**	-	-	**2**
Liriomyza sonchi Hendel, 1931	-	-	**1**
Liriomyza trifolii (Burgess in Comstock, 1880)	**2**	-	**30**
***Liriomyza* n. sp. 1**	**1**	-	-
***Liriomyza* n. sp. 2**	-	**2**	-
***Liriomyza* n. sp. 3**	-	-	**6**
***Liriomyza* n. sp. 4**	**-**	-	**1**
Metopomyza scutellata (Fallén, 1823)	**2**	-	-
***Metopomyza* n. sp. 1**	**1**	-	-
Napomyza lateralis (Fallén, 1823)	**85**	**1**	-
Phytobia carbonaria (Zetterstedt, 1848)	-	**1**	-
***Phytobia cerasiferae* (Kangas, 1955)**	**1**	-	-
Phytobia errans (Meigen 1830)	-	**1**	-
***Phytobia lunulata* (Hendel, 1920)**	-	**10**	**1**
Phytoliriomyza arctica (Lundbeck, 1901)	**34**	-	-
Phytoliriomyza perpusilla (Meigen, 1830)	**3**	**3**	-

Phytomyza albipennis Fallén, 1823	**1**	-	-
***Phytomyza bupleuri* Hering, 1963**	-	**1**	-
Phytomyza clematidis Kaltenbach, 1859	**1**	-	-
Phytomyza crassiseta Zetterstedt, 1860	**31**	**7**	-
Phytomyza gymnostoma Loew, 1858	**1**	-	-
Phytomyza plantaginis Robineau-Desvoidy, 1851	**18**	-	**17**
Phytomyza ranunculi (Schrank, 1803)	**4**	**1**	-
Phytomyza rufipes Meigen, 1830	**64**	**1**	**22**
Phytomyza sedi Kaltenbach, 1869	-	-	**2**
Phytomyza tanaceti Hendel, 1923	-	**10**	-
***Phytomyza* n. sp. 1**	**1**	-	-
***Phytomyza* n. sp. 2**	**2**	-	-
***Phytomyza* n. sp. 3**	**1**	-	-
***Phytomyza* n. sp. 4**	**4**	-	-
***Phytomyza* n. sp. 5**	**3**	-	-
Pseudonapomyza atra (Meigen, 1830)	**85**	-	-
***Pseudonapomyza atratula* Zlobin, 2002**	-	**1**	**180**
Pseudonapomyza europaea Zlobin, 2002	**1**	-	-
Pseudonapomyza hispanica Spencer, 1973	**2**	-	-
***Pseudonapomyza palliditarsis* Cerny, 1992**	**2**	-	-
Pseudonapomyza spinosa Spencer, 1973	**15**	**9**	**39**
Pseudonapomyza strobliana Spencer, 1973	**2**	-	-
Pseudonapomyza vota Spencer, 1973	**30**	-	**2**
Pseudonapomyza sp. 1	**2**	-	-
Pseudonapomyza sp. 2	**22**	-	**1**
Pseudonapomyza sp. 3	-	**84**	**-**
Pseudonapomyza sp. 4	-	**1**	**-**
***Pseudonapomyza curvata* n. sp.**	**3**	**8**	-
***Pseudonapomyza benifassae* n. sp.**	**8**	**1**	-
***Pseudonapomyza longitata* n. sp.**	**1**	**107**	**7**
***Pseudonapomyza mediterranea* n. sp.**	-	**-**	**5**
***Pseudonapomyza sicicornis* n. sp.**	**1**	-	-
Ptochomyza asparagi Hering, 1942	**23**	**5**	**4**
PHYTOMYZINAE RICHNESS	**60**	**28**	**25**
TOTAL RICHNESS	**89**	**38**	**37**

Table 5-5. Quantitative summary of the number of species captured in the Natural Parks of “Tinença de Benifassà”, “Font Roja” and “Lagunas de La Mata-Torrevieja”. Species listed in bold are new reports for Spain or new species for the science (n. sp.).

Captures have been studied globally carrying out an analysis of the variance (ANOVA) (Table 5-6). The ANOVA decomposes the variance of the data into two components: one between-groups and other within-groups. A great difference is observed between captures registered in the “Lagunas de La Mata-Torrevieja” and the other two Natural Parks studied. The F-ratio, which in this case equals 4,699, is a ratio of the between-group estimate and the within-group estimate. Since the P-value of the F-test is less than 0,05, there is a statistically significant difference between the means of the 3 variables at the 95% confidence level.

Analysis of Variance

Source	Sum of squares	df	Mean square	F-Ratio	P-Value
Between groups	32355,1	2	16177,6	4,7	0,0104
Within groups	557679	162	3442,46		
Total (Corr.)	590034	164			

Table 5-6. Analysis of variance of the captures taken in the Natural Parks of “Tinença de Benifassà”, “Font Roja” and “Lagunas de La Mata-Torrevieja”.

The intervals are graphically represented based on Fisher’s least significant difference (LSD) procedure (Fig. 5-105). They are constructed in such a way that if two means are the same, their intervals will overlap 95% of the time. These intervals are used to determine which means are significantly different from which others. It is noted that the average of captures in the Natural Park of the “Lagunas de La Mata-Torrevieja” are significant at 95% like has been indicated in the ANOVA table.

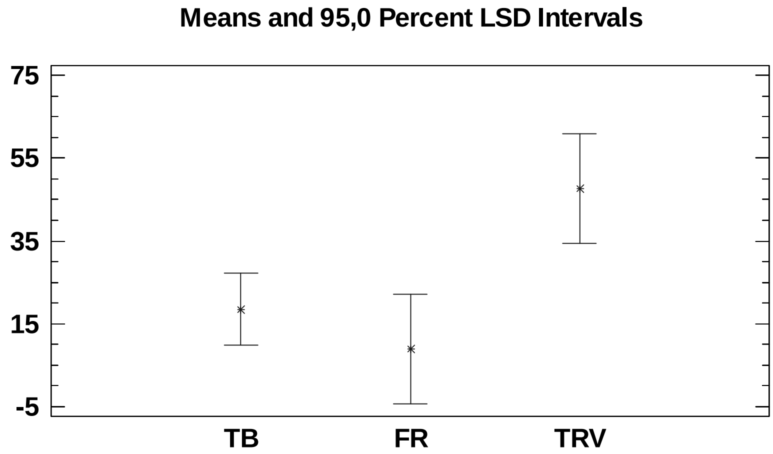

Figure 5-105. Graphical representation of the means of the captures belonging to the Natural Parks of “Tinença de Benifassà” (TB), “Font Roja” (FR) and “Lagunas de La Mata-Torrevieja” (TRV) based on Fisher's least significant difference (LSD) procedure.

Despite the Natural Park of “Tinença de Benifassà” differs in captures with the specific richness of “Font Roja” and “Lagunas de La Mata-Torrevieja”, only this one presents globally significant differences between the other two. It is thought that such differences are related to the particular bioclimatic conditions of each park. High temperatures (>35ºC) recorded from mid-May makes most of the broad-leaved plants disappear very quickly. This makes mild winters present in the “Lagunas de La Mata-Torrevieja” offer bioclimatic conditions suitable for the development of Agromyzidae. In general, captures tend to be decompensate regarding the abundance of species, because few species globally support all captures reported. These are the reasons because eventhough the “Font Roja” and the “Lagunas de La Mata-Torrevieja” have similar richness species of the analysis of variance present results are so different. “Tinença de Benifassà” and “Font Roja” present species with more balanced abundances, although there are also dominant species.

5.6.1 Alpha biodiversity study

Alpha diversity refers to the species composition typical of a particular place, being the simplest way of assessing the biodiversity. Its measurement is established by the species richness, the dominance in the relative abundance of some species, the equity in the relative abundance among all species, or through the joint information in a single index of species richness and equity (MARGALEF, 1988).

Figure 5-106 summarizes the indices and models used to evaluate the biodiversity of the Natural Parks under study. The indices used to measure the species richness were Margalef and Menhinick. Among the indices that measure the degree of dominance two have been considered, Simpson and Berger-Parker. The equity in the proportional abundance was measured with parametric models (logarithmic series, log-normal distribution and broken stick model) and the index of Shannon-Wiener classic.

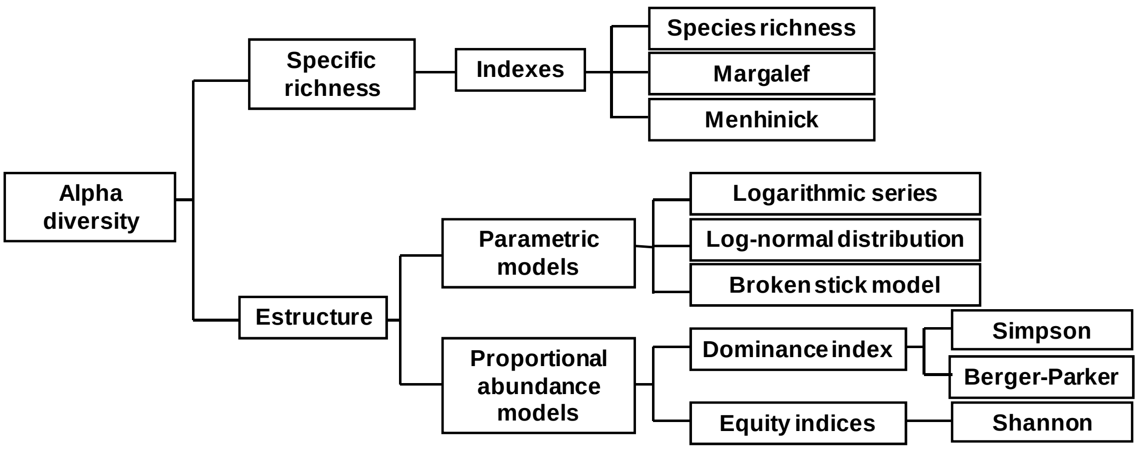

Figure 5-106. Schematic diagram of indices and models used to estimate the alpha biodiversity in each of the naturals parks studied.

The species richness is the simplest method of evaluating the diversity by providing timely information about the ecological and historical processes. A major disadvantage is that the diversity measurement in this way depends on the size of the sample, and therefore a larger sampling effort is most likely to find a larger number of species. Thus, the sampling effort has been standarized to compare the three national parks studied. In turn, the information provided has been compared with the models that measure the structure of the community (parametric models and proportional abundance).

Although data on species abundance are often described by one or more families of distributions (PIELOU, 1975), the biodiversity has been examined on the basis of three main models. These are the logarithmic normal distribution, the logarithmic series and the broken stick model of MacArthur. The logarithmic series represents a situation where a few dominant species take precedence over a large portion of the niche hyperspace, while the broken stick model reflects a minimal case of preference, with divided resources in a much more equitable way. The geometric series has been discarded in our study because it is most commonly applied to poor-species associations.

Each model has a characteristic form of cartesian graphic of rank/abundance (WHITTAKER, 1977). The geometric series appears as a straight line with a pronounced gradient. Equally the logarithmic series also has a pronounced gradient, but here the curve is only approximately linear. The flattest curve is provided by the broken stick model. Between the logarithmic series and broken stick model it shows a normal curve with its logarithmic sigmoid curve. The data was analyzed, if possible, to investigate how it adjusted to each one of these models (Fig. 5-107).

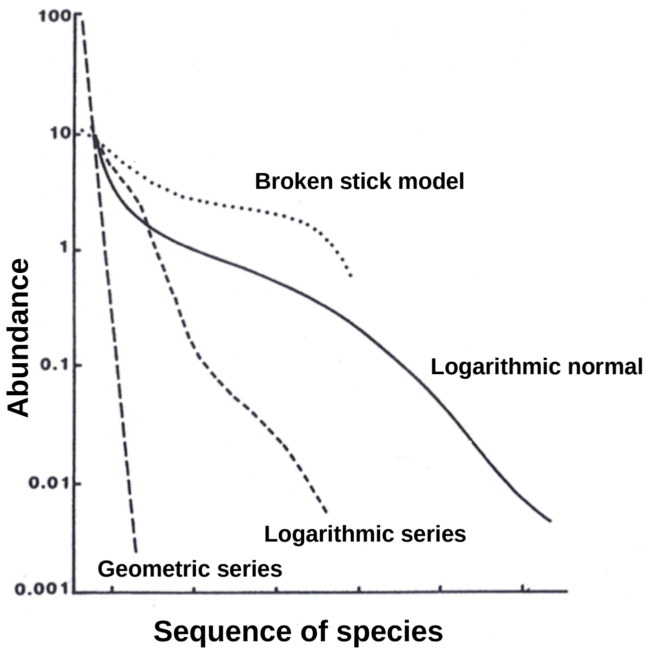

Figure 5-107. Hypothetical curves that illustrate the typical shape of the four models according to rank/abundance: geometric series, logarithmic series, log normal and broken stick. In these graphs the abundance of each species is represented in a logarithmic scale against the species that occupies the rank ordered from most abundant to least abundant. The abundance of species may often be expressed as a percentage for a more direct comparison between communities with different numbers of species (MAGURRAN, 1988).

The most widely used measures of biodiversity are the index of biodiversity that are based on the logic of biodiversity, and the information provided by captures that finally are materialized into a mathematical figure. The main parameters of alfa biodiversity statistical analysis are indicated in Table 5-7.

	Discriminatory capacity	Sensitivity to sample size	Richness or dominance uniformity	Simplicity of calculation	Breadth of use
α (logarithmic series)	Good	Low	Richness	Simple	Yes
λ (normal logarithmic)	Good	Moderate	Richness	Complex	No
Q statistic	Good	Low	Richness	Complex	No
S (species richness)	Good	High	Richness	Simple	Yes
Margalef index	Good	High	Richness	Simple	No
Shannon index	Moderate	Moderate	Richness	Intermediate	Yes
Brillouin index	Moderate	Moderate	Richness	Complex	No
U index of McIntosh	Good	Moderate	Richness	Intermediate	No
Simpson index	Moderate	Low	Dominance	Intermediate	Yes
Berger-Parker index	Poor	Low	Dominance	Simple	No
Uniformity Shannon	Poor	Moderate	Uniformity	Simple	No
Uniformity Brillouin	Poor	Moderate	Uniformity	Complex	No
D index of McIntosh	Poor	Moderate	Dominance	Simple	No

Table 5-7. Summary of the behaviour and main characteristics of a different statistical parameters of diversity. This table gives us an idea of the discriminatory power between indexes depending on the sampling design used (MAGURRAN, 1988).

Both indexes of biodiversity as the models have been shown mathematically summarized in Table 5-8. The specified mathematical formulas have been used to characterize and compare the ecology of biodiversity associated with each of the Natural Parks studied.

Margalef

$$d = \frac{(S-1)}{\ln N}$$

S : species richness; N : total number of individuals

Menhinick

$$d = \frac{S}{\sqrt{N}}$$

Berger-Parker

$$d = \frac{N_{\max}}{N}$$

$N_{\max} =$ number of individuals of the most abundant species

$N_{\infty} =$ reciprocal of the Berger-Parker index

Logarithmic series

$$\alpha x, \frac{\alpha x^2}{2}, \frac{\alpha x^3}{3}, \ldots \frac{\alpha x^n}{n}$$

$\alpha x =$ expected number of species with a single individual,
$\alpha x^2 / 2$ those individuals who have 2, and so on (Fisher *et al.*, 1943; Poole,1974).

$$S = \alpha\left[-\ln(1-x)\right] \; ; \; S/N = (1-x)/x\left[-\ln(1-x)\right]$$

Two parameters, α, the index of the series and logarithmic N, distribution and summary are completely interconnected by
$N = \alpha \ln\left(1 + \frac{N}{\alpha}\right)$, α is a biodiversity index (Taylor, 1978),
$\alpha = \frac{N(1-x)}{x}$, and $Var(\alpha) = \frac{\alpha}{-\ln(1-x)}$

Log-normal distribution

$$S(R) = S_0 \exp\left(-a^2 R^2\right)$$

$S(R) =$ number of species of R-th eight (=class) to the right and left of the symmetrical curve.
$S_0 =$ number of species in the eighth modal
$a = \left(2\sigma^2\right)^{1/2} =$ inverse amplitude distribution

Broken stick model

$$N_i = N/S\sum_{n=1}^{S} 1/n$$

$N =$ total number of individuals
$S =$ total number of species

expressing the model in terms of abundance distribution of typical species (May, 1975),

$$S(n) = \left[S(S-1)/N\right](1-n/N)^{S-2}$$

$S(n) =$ species number in the abundance class that presents n individuals.

Shannon

$$H' = -\sum p_i \ln p_i$$

$p_i = n_i / N$, proportion of species found in the i-th (Pielou, 1969).

Simpson

$$d = 1 - \sum_{i=1}^{S} p_i^2$$

Table 5-8. Summary of mathematical formulas that characterize each one of the indexes and mathematical models used to estimate the alpha biodiversity.

5.6.1.1 Relative abundance

The interspecific and intergeneric relative abundance evaluate comprehensively what the most abundant species and genera are. This tool allows us to easily see which are the dominant species and genera. A distribution of species abundance use the information accumulated in the community and is the most complete mathematical description of the data.

Table 5-9 shows the number of individuals captured by Agromyzidae genera for each of the Natural Parks studied.

AGROMYZIDAE ABUNDANCE			
AGROMYZINAE SUBFAMILY	**Tinença de Benifassà**	**Font Roja**	**Lagunas de La Mata-Torrevieja**
Agromyza	*122*	*3*	*557*
Melanagromyza	*95*	*0*	*0*
Ophiomyia	*226*	*71*	*56*
AGROMYZINAE ABUNDANCE	***443***	***74***	***613***
PHYTOMYZINAE SUBFAMILY	**Tinença de Benifassà**	**Font Roja**	**Lagunas de La Mata-Torrevieja**
Amauromyza	*10*	*1*	*0*
Aulagromyza	*92*	*0*	*134*
Calycomyza	*7*	*0*	*4*
Cerodontha	*20*	*3*	*27*
Chromatomyia	*33*	*2*	*0*
Liriomyza	*467*	*8*	*194*
Metopomyza	*3*	*0*	*0*
Napomyza	*85*	*1*	*0*
Phytobia	*1*	*12*	*1*
Phytoliriomyza	*37*	*3*	*0*
Phytomyza	*131*	*20*	*41*
Pseudonapomyza	*174*	*209*	*234*
Ptochomyza	*23*	*5*	*4*
PHYTOMYZINAE ABUNDANCE	***1083***	***264***	***639***
TOTAL ABUNDANCE	**1526**	**338**	**1252**

Table 5-9. Breakdown of the abundance of specimens captured by Agromyzidae genera in each of the parks studied.

The results presented in Table 5.9 are graphically represented in Figures 5-108, -109 and -110. In view of the graphs it shows that there is a large difference in the composition of more frequent genera for each of the parks studied.

In "Tinença de Benifassà" (Fig. 5-108), 3 groups of genera can be distinguished from most to least predominant. It highlights the occurrence of the genus *Liriomyza* (28.4%), *Ophiomyia* (13.7%) and *Pseudonapomyza* (10.6%) with percentages between 10-15%. Subsequently, the remaining genera show a frequency of occurrence of less than 10% led by *Phytomyza* (8%) and *Agromyza* (7.4%).

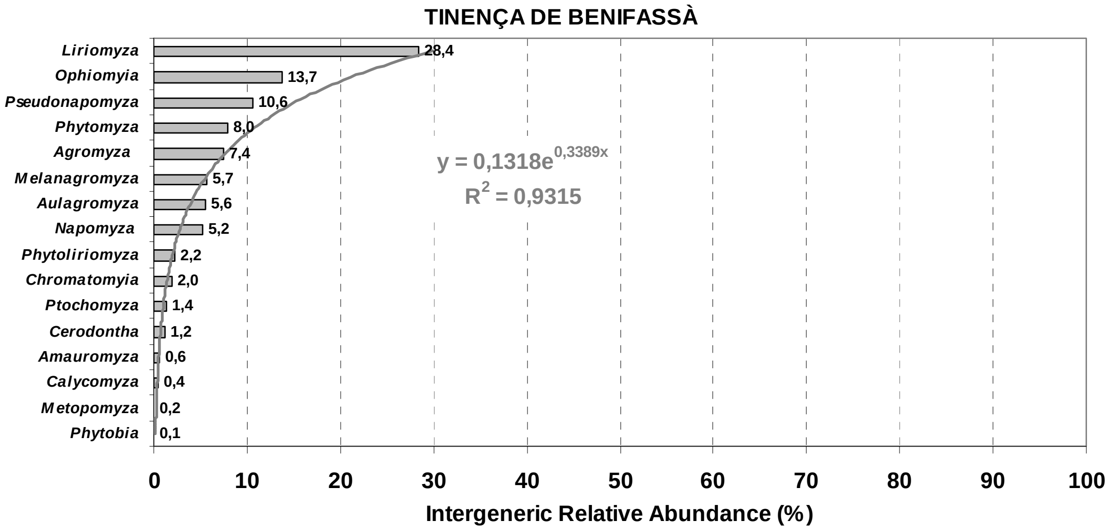

Figure 5-108. Intergeneric relative abundance of Agromyzidae in the Natural Park of "Tinença de Benifassà".

In the Natural Park of "Font Roja" (Fig. 5-109) it shows that the two genera are dominated by *Pseudonapomyza* (61.3%) and *Ophiomyia* (21%). The other genera are of less frequency of occurrence than 6%.

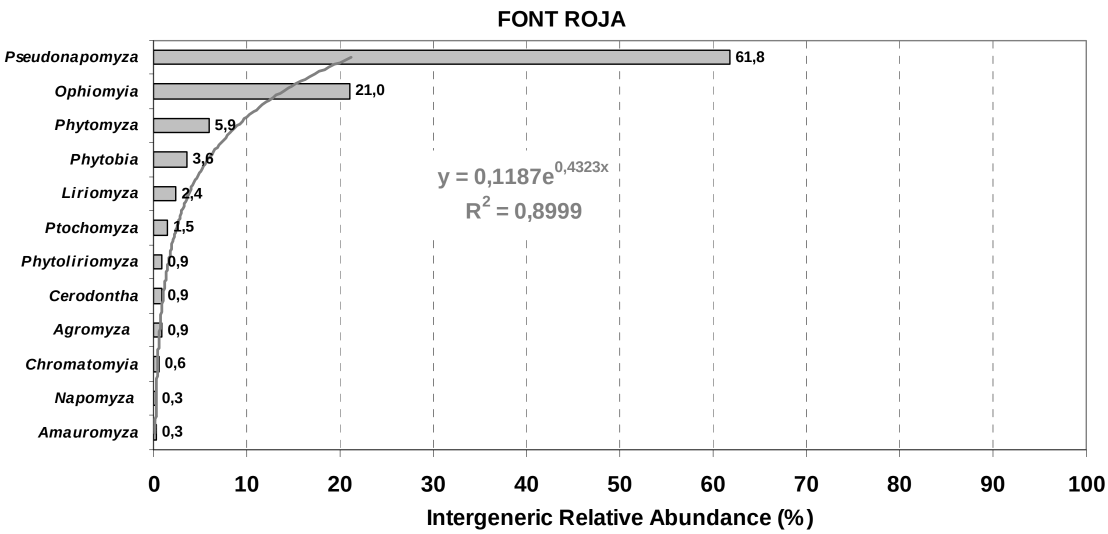

Figure 5-109. Intergeneric relative abundance of Agromyzidae in the Natural Park of "Font Roja".

In the Natural Park of the "Lagunas de La Mata-Torrevieja" (Fig. 5-110) *Agromyza* genus (30.8%) predominates, followed by the genera *Pseudonapomyza* (12.9%) and *Liriomyza* (10.7%). Occurrence of other genera is less than 10%.

In the Natural Park of "Tinença de Benifassà" there are no great differences between genera, but the predominance of the genus *Liriomyza* indicates the presence of crops near the placement of the Malaise trap. In "Font Roja", the great predominance of the genus *Pseudonapomyza* indicates that the placement of the trap is mainly dominated by agromyzids of monocotyledons plants. In the "Lagunas de La Mata-Torrevieja" the predominant genera are *Agromyza* and *Pseudonapomyza*, almost exclusively of grass miners.

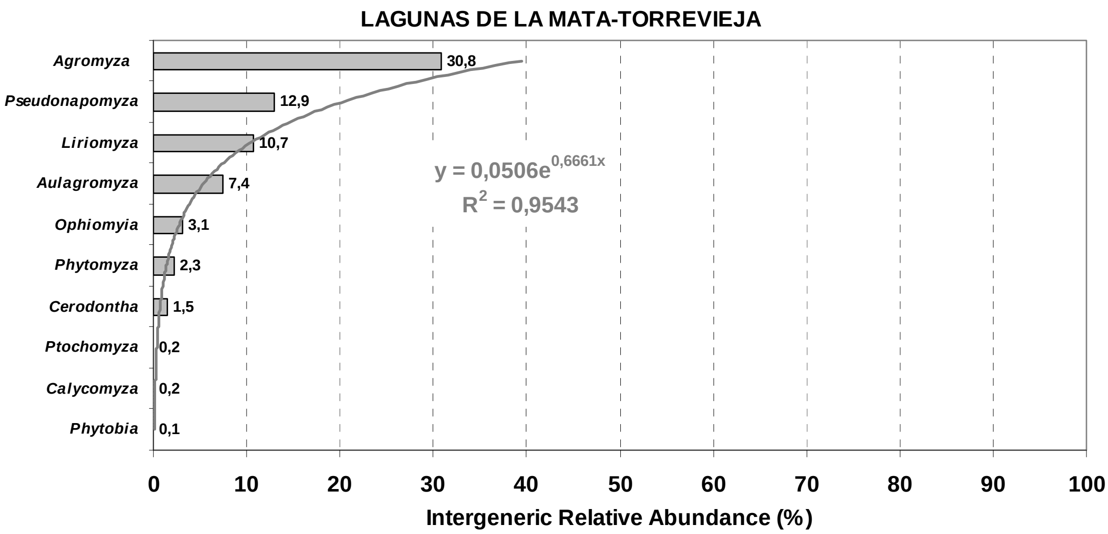

Figure 5-110. Intergeneric relative abundance of Agromyzidae in the Natural Park of Las "Lagunas de La Mata-Torrevieja".

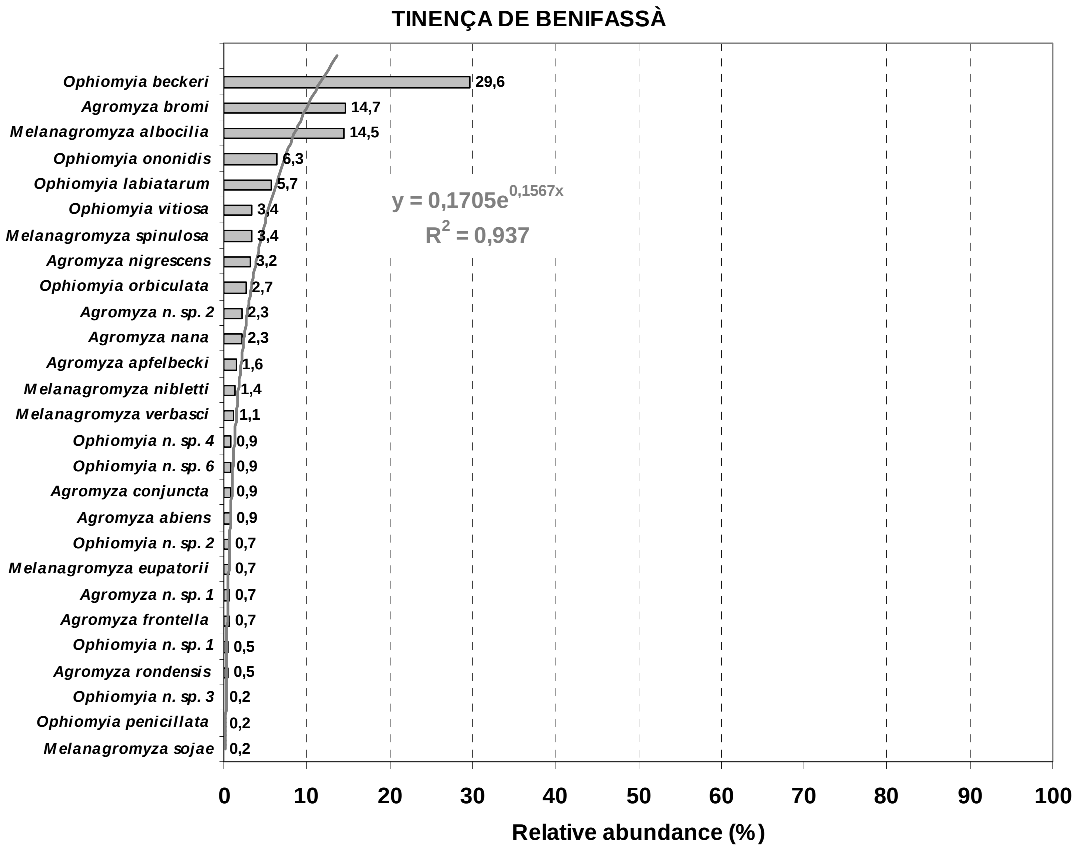

Figure 5-111. Interspecific relative abundance of Agromyzinae in the Natural Park of "Tinença de Benifassà".

Within the Agromyzinae family in the Natural Park of "Tinença de Benifassà" it highlights *Ophiomyia beckeri* (29.6%), *Agromyza bromi* (14.7%) and *Melanagromyza albocilia* (14.5%) species. The rest of species present relative abundances at percentages below 10% (Fig. 5-111).

In the Natural Park of "Font Roja" it stresses the presence of *Ophiomyia beckeri* (66.2%), and a new species of *Ophiomyia* n. sp. 1 (17.6%) (Fig. 5-112). Biodiversity of species in comparison with the Natural Park of "Tinença de Benifassà" is three times smaller, being composed exclusively of species of *Ophiomyia* and *Agromyza*.

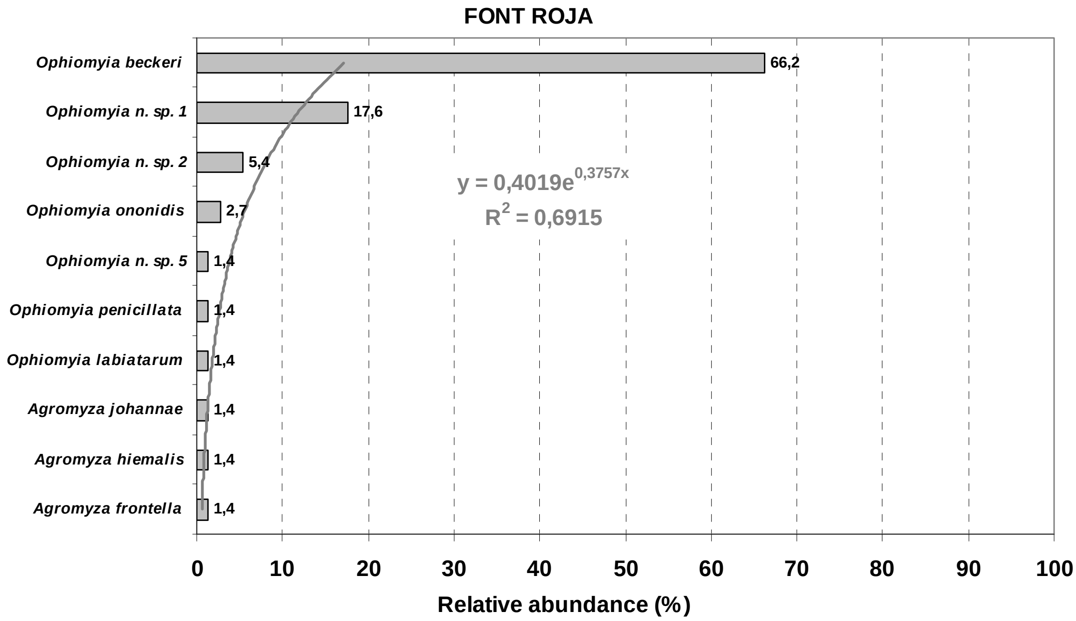

Figure 5-112. Interspecific relative abundance of Agromyzinae in the Natural Park of "Font Roja".

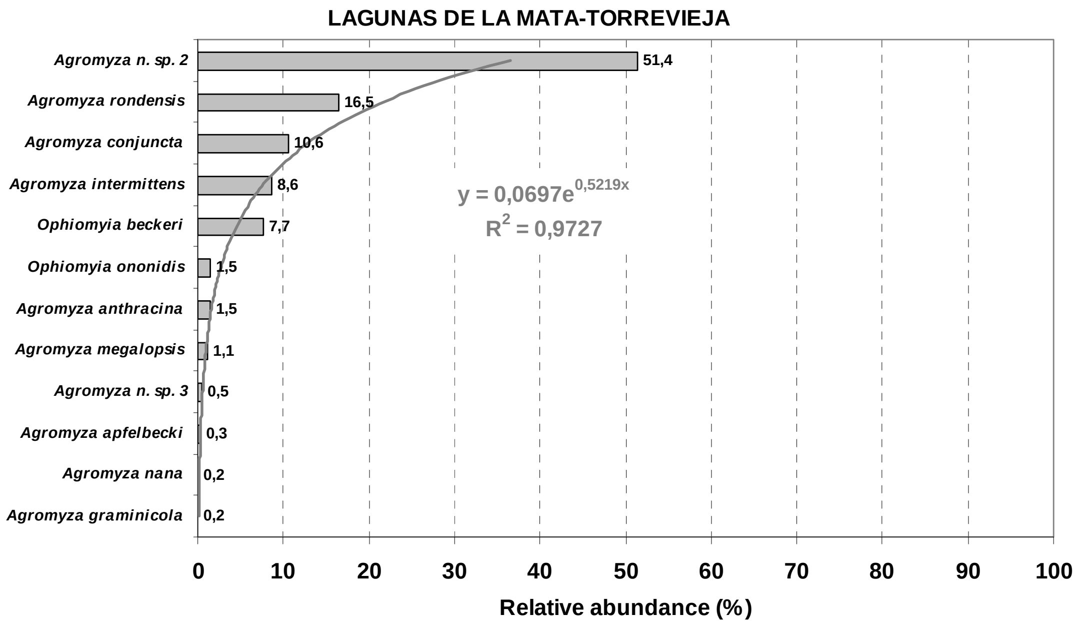

Figure 5-113. Interspecific relative abundance of Agromyzinae in the Natural Park of "Lagunas de La Mata-Torrevieja".

In the Natural Park of the “Lagunas de La Mata-Torrevieja” it highlights the presence of a new species of *Agromyza* (51.4%), *Agromyza rondensis* (16.5%) and *Agromyza conjuncta* (10.6%) (Fig. 5-113). The quantitative biodiversity in this park is very similar to “Font Roja”.

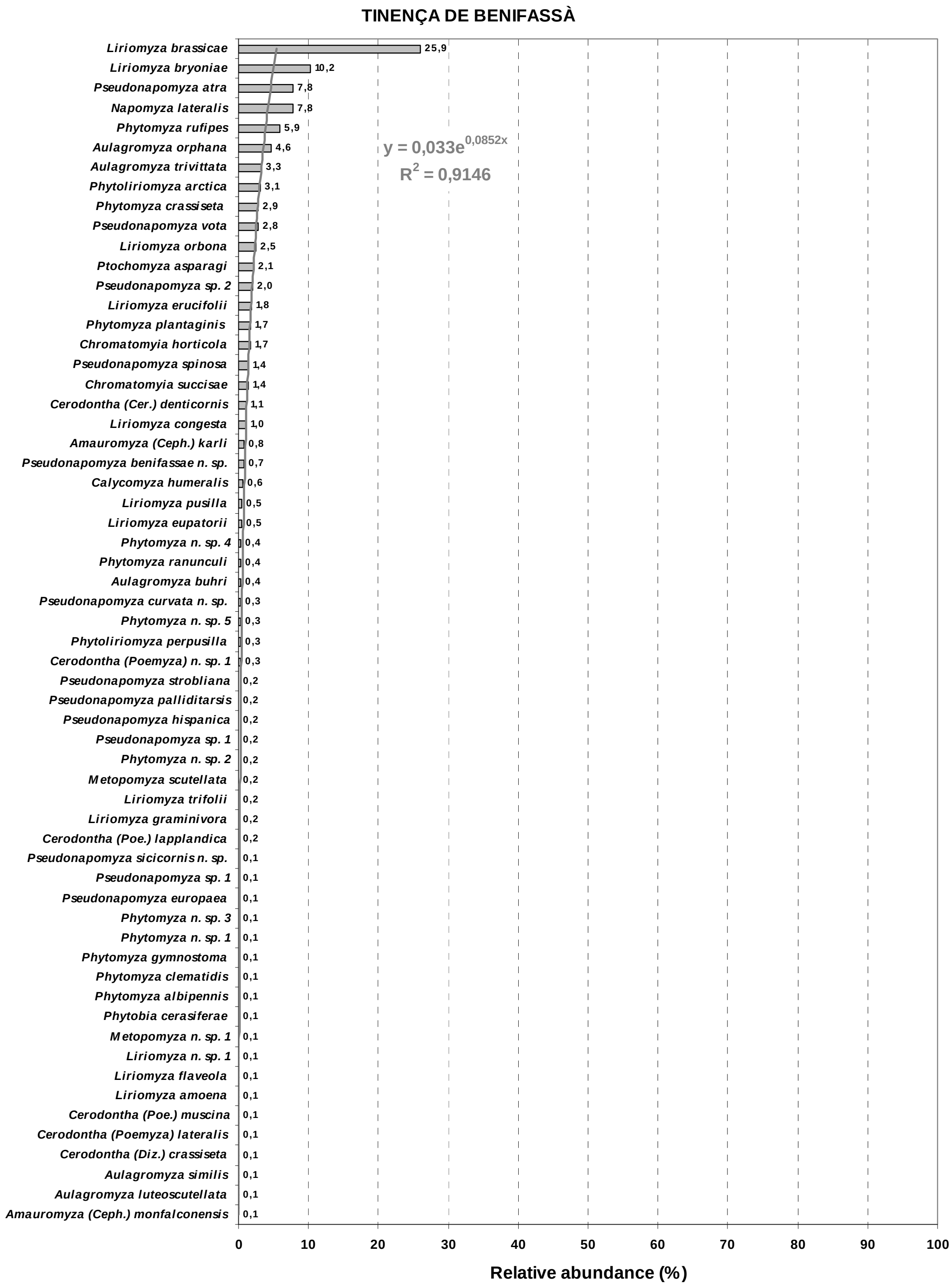

Figure 5-114. Interspecific relative abundance of Phytomyzinae in the Natural Park of “Tinença de Benifassà”.

Within the Phytomyzinae family in the Natural Park of "Tinença de Benifassà" it highlights two *Liriomyza* species, *L. brassicae* (25.9%) and *L. bryoniae* (10.2%). The rest of the species present relative abundances of percentages below 10% (Fig. 5-114). The presence of greenhouses next to the park means that certain natural populations of *Liriomyza* are available on host-plants where they grow almost throughout the year.

In the case of the Natural Park of "Font Roja" it highlights two new species of *Pseudonapomyza* (Fig. 5-115). The Malaise trap is located next to wheat crops and grass meadows, so it is logical that the predominant species belong to the *Pseudonapomyza* genus miners of monocotyledons plants in temperate zones.

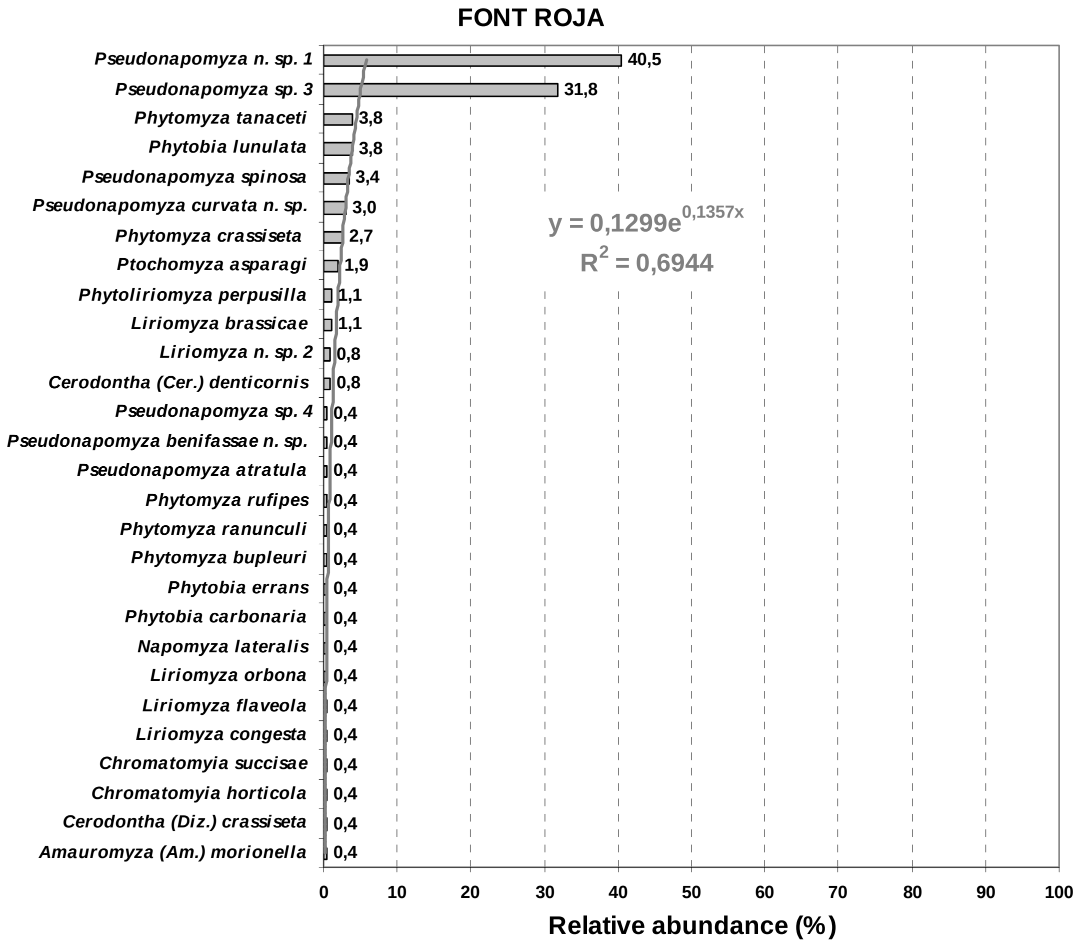

Figure 5-115. Interspecific relative abundance of Phytomyzinae in the Natural Park of "Font Roja".

In the Natural Park of the "Lagunas de La Mata-Torrevieja" the presence of *Pseudonapomyza atratula* (28.6%) is stressed, followed by *Liriomyza orbona* (20.8%), *Aulagromyza trivittata* (10.5%) and *Aulagromyza luteoscutellata* (10.5%) (Fig. 5-116).

Independently of the adjustment models traditionally used and widely developed later, it appears that the captures have been adjusted with a very high percentage of correlation to an exponential fit. The best adjustments were obtained for the Natural Park of the "Lagunas de La Mata-Torrevieja" with $R^2_{\text{Agromyzinae}}= 0.9727$ and $R^2_{\text{Phytomyzinae}}= 0.9644$. In the case of "Tinença de Benifassà" the adjustments have been somewhat lower but in any case higher than 0.9 ($R^2_{\text{Agromyzinae}}= 0.937$ and $R^2_{\text{Phytomyzinae}}= 0.9146$). In the Natural Park of "Font Roja" the presence of high captures of few dominant species in respect of the rest makes adjustments to the exponential model much lower than in the other two cases mentioned above, where the order of correlation was 0.69 for both, Agromyzinae and Phytomyzinae families.

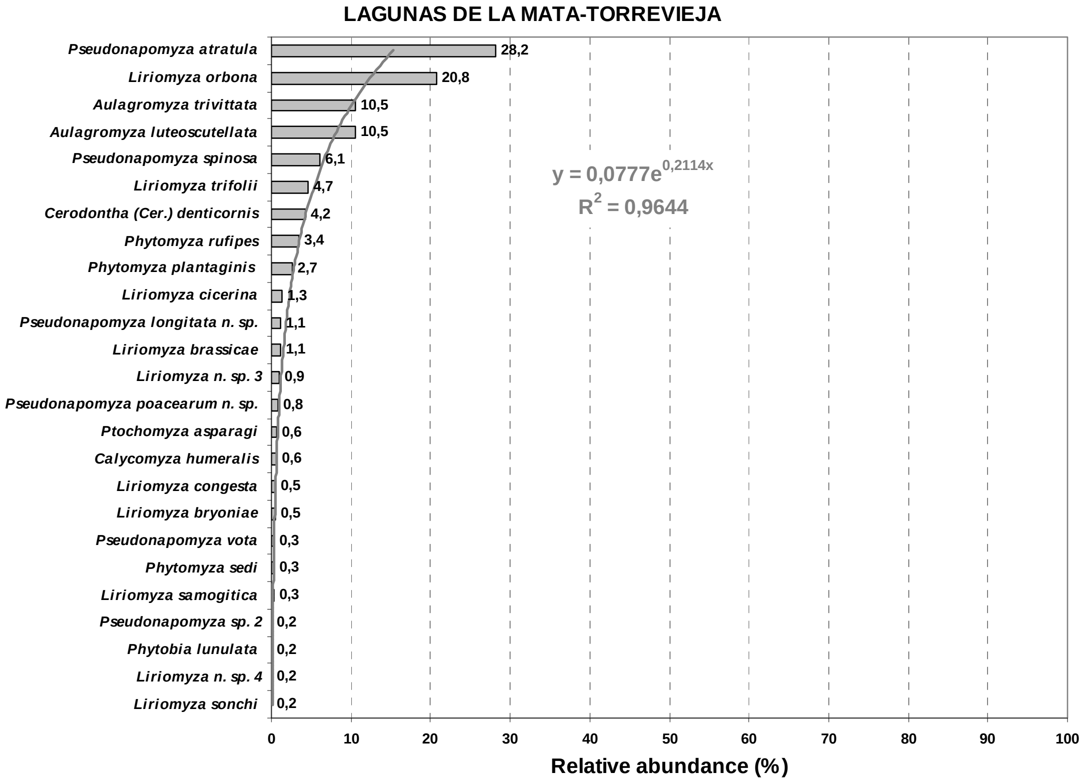

Figure 5-116. Interspecific relative abundance of Phytomyzinae in the Natural Park of “Lagunas de La Mata-Torrevieja”.

The Figure 5-117 shows the Agromyzinae species abundance captured in each Natural Park, indicating the number of species that are common and not common among them. It is noted that the more frequent species are established between the Natural Park of “Tinença de Benifassà” and the other two parks. Moreover, “Tinença de Benifassà” has the highest number of exclusive species. The opposite is the Natural Park of “Font Roja” with the least number of exclusive species.

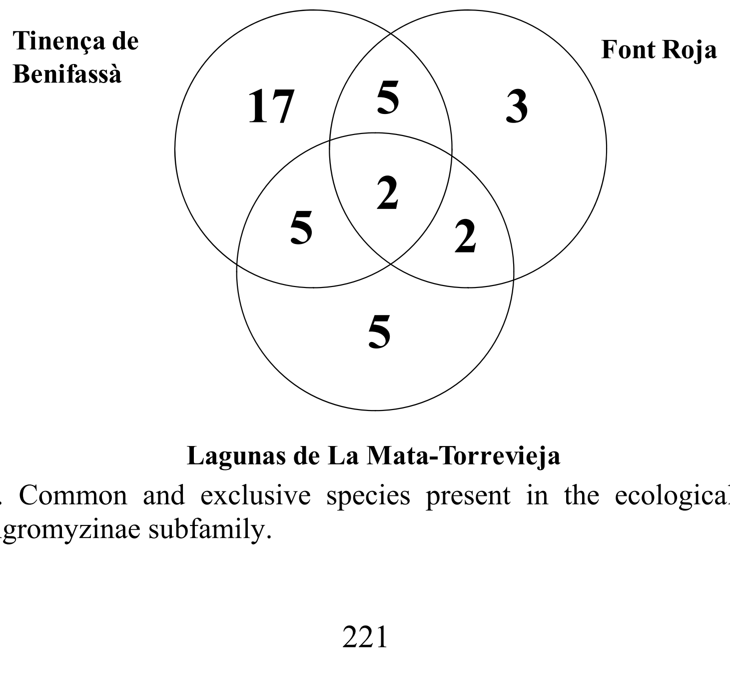

Figure 5-117. Common and exclusive species present in the ecological communities studied into Agromyzinae subfamily.

The abundance species of between parks for the subfamily Phytomyzinae is illustrated in Figure 5-118. The same behaviour is observed as in the subfamily Agromyzinae, with “Tinença de Benifassà” being the park with the most natural biodiversity present. Also, the more frequent species are established between the Natural Park of “Tinença de Benifassà” and the other two parks.

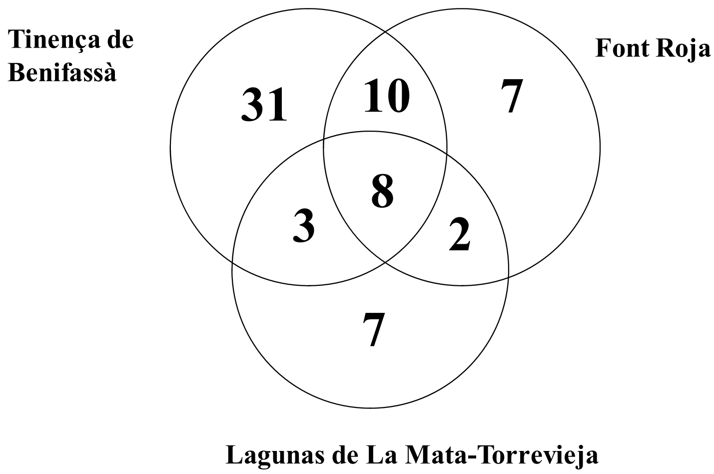

Figure 5-118. The common and exclusive species present in the ecological communities studied in Phytomyzinae subfamily.

5.6.1.2 Parametric models

Logarithmic series

The Fisher's model of logarithmic series (FISHER *et al.*, 1943) was applied and it attempts to describe mathematically the relationship between the number of species and number of individuals of these species. A logarithmic series model occurs when the intervals between the arrivals of the species is more chance than normal (BOSWELL & PATIL, 1971; MAY, 1975). It is particularly related to situations in which one or a few factors dominate the ecological relationships of the community.

The procedure for predicting the model is to calculate the expected number of species in each abundance class and to compare them with the number of species currently observed using the fit goodness test (χ^2 or G test, SOKAL & ROHLF, 1981) (TABLE 5-10).

It is noted that the only capture trends that fit to this model are the Natural Parks of “Tinença de Benifassà” and “Font Roja” within Phytomyzinae, and the “Lagunas de La Mata-Torrevieja” in total captures. The main factors that determine the captures are the presence of host-plants and a favorable climate. It is noted that the adjustment to a log-normal distribution does not occur in all cases, this suggests that the phenology of Agromyzidae is influenced by other factors such as the presence of parasitoids, chemical treatments, etc.

Clase	Upperbound	EXPECTED NUMBER OF SPECIES								
		AGROMYZINAE			PHYTOMYZINAE			TOTAL		
		TB	FR	TRV	TB	FR	TRV	TB	FR	TRV
1	2.5	9.78	4.43	3.21	13.28	11.17	8.13	30.76	15.80	11.25
2	4.5	3.69	1.58	1.24	5.08	4.08	3.10	11.63	5.75	4.32
3	8.5	3.84	1.53	1.33	5.39	4.09	3.29	12.16	5.70	4.62
4	16.5	3.68	1.26	1.37	5.37	3.63	3.28	11.75	4.96	4.66
5	32.5	3.18	0.81	1.34	4.99	2.67	3.04	10.29	3.53	4.45
6	64.5	2.29	0.33	1.25	4.19	1.42	2.53	7.65	1.76	3.92
7	128.5	1.19	-	1.07	2.90	0.42	1.73	4.20	0.45	2.99
8	256.5	0.33	-	0.78	1.41	-	0.82	1.31	-	1.76
9	512.5	-	-	0.42	0,35	-	-	0.15	-	0.62
10	1024.5	-	-	-	-	-	-	-	-	-
11	∞	-	-	-	-	-	-	-	-	-
Clase	**Upperbound**	χ^2								
		AGROMYZINAE			PHYTOMYZINAE			TOTAL		
		TB	FR	TRV	TB	FR	TRV	TB	FR	TRV
1	2.5	1.46	1.49	0.01	16.32	4.17	0.16	0.34	5.36	0.14
2	4.5	5.05	0.21	0.05	0.73	1.07	0.26	0.98	1.31	0.11
3	8.5	0.18	1.53	0.08	0.36	0.29	0.88	2.19	1.28	0.41
4	16.5	1.46	0.05	0.29	0.03	0.11	3.28	0.05	0.19	1.52
5	32.5	0.44	0.81	1.34	1.80	2.67	0.30	0.01	3.53	0.04
6	64.5	0.73	1.33	0.45	0.008	1.42	0.92	0.92	0.33	0.22
7	128.5	0.03	-	0.80	0.003	6.04	0.04	0.01	5.24	0.33
8	256.5	1.33	-	0.78	1.40	15.78	1.71	0.07	-	0.03
9	512.5	-	-	0.80	1.21	-	7.55	5.02	-	0,23
10	1024.5	-	-	-	-	-	-	9.58	-	-
11	∞									

	AGROMYZINAE			PHYTOMYZINAE			TOTAL		
	TB	FR	TRV	TB	FR	TRV	TB	FR	TRV
$\sum \chi^2$	10.67	5.43	4.61	21.87	15.78	7.55	9.58	17.24	3.04
d.g	7	5	8	8	6	7	8	6	8
$Table\ \chi^2$	P=0.05 14.07	P=0.05 11.07	P=0.05 15.51	P=0.05 15.51	P=0.05 12.59	P=0.05 14.067	P=0.05 15.51	P=0.05 12.59	P=0.05 15.527
	P=0.01 12.02	P=0.3 6.06	P=0.7 5.53	P=0.01 20.09	P=0.02 15.03	P=0.3 8.38	P=0.2 11.03	P=0.01 16.81	-
Significance	No	No	No	Yes	Yes	No	No	Yes	Yes

Table 5-10. Summary of adjusted calculation of captures in the logarithmic series model. It shows the expected number of species, the calculated χ^2 and the degree of significance.

Log-normal distribution

Most of the communities studied by ecologists present a log-normal model of species abundance (SUGIHARA, 1980). The log-normal distribution is based on the Limit Central Theorem (MAY, 1975), which states that when a variable is influenced by many factors, the response of the studied variable usually follows a normal distribution. This effect is more real as the number of determinants increases. In the case of the logarithmic normal distribution of species abundance data, the variable is the number of individuals per species (characterized by a logarithmic transformation) and the determinants are all processes that govern the ecological community.

In the case of adjusting to normal logarithmic series shown in Table 5-11, it highlights that only occurs in the case of the Natural Park of "Font Roja". The trap placed in this park mean that captures produced are fairly homogeneous in monocots miners. This uniformity in the fluctuation of captures means that adjustment is more favorable to a logarithmic normal distribution. However, obtaining a great difficulty in adjusting captures to a logarithmic series and to the log-normal series suggests the presence of high captures of few dominant species in respect of the rest.

	AGROMYZINAE			**PHYTOMYZINAE**			**TOTAL**		
	TB	**FR**	**TRV**	**TB**	**FR**	**TRV**	**TB**	**FR**	**TRV**
$\overline{\chi}$	0,79	0,37	1,10	0,68	0,39	0,89	0,72	0,38	0,96
σ^2	0,27	0,31	0,63	0,46	0,32	0,45	0,41	0,33	0,52
γ	0,22	0,67	0,32	0,47	0,68	0,32	0,39	0,70	0,33
θ	0,03	2,04	0,12	0,49	2,16	0,12	0,25	2,51	0,13
μ_χ	0,76	-1,00	0,93	0,20	-1,10	0,74	0,46	-1,34	0,79
V_χ	0,31	1,23	0,87	0,93	1,35	0,63	0,67	1,51	0,73
Z_0	-1,93	0,63	-1,33	-0,52	0,69	-1,32	-0,94	0,84	-1,27
P_0	0,03	0,26	0,09	0,30	0,25	0,09	0,17	0,20	0,10
S^*	28,77	13,59	13,21	85,90	37,09	27,58	106,48	47,53	41,20

Clase	$\mathbf{L_{up}}$	$\mathbf{Log_{10}L_{up}}$	**EXPECTED NUMBER OF SPECIES**								
			AGROMYZINAE			**PHYTOMYZINAE**			**TOTAL**		
			TB	**FR**	**TRV**	**TB**	**FR**	**TRV**	**TB**	**FR**	**TRV**
	0.5	-0.301	0.79	1.16	1.21	25.90	28.22	2.62	18.49	38.00	4.20
1	2.5	0.398	6.54	2.80	2.50	23.86	5.34	6.58	31.36	5.76	9.10
2	4.5	0.653	4.78	1.13	1.33	8.72	1.19	3.38	13.09	1.27	4.68
3	8.5	0.929	5.68	1.40	1.51	8.12	0.91	3.82	13.28	0.97	5.24
4	16.5	1.217	5.06	1.77	1.61	6.79	0.60	3.61	11.23	0.64	5.26
5	32.5	1.512	3.38	0.84	1.51	4.96	0.39	2.99	8.36	0.41	4.46
6	64.5	1.810	1.70	1.01	1.24	3.39	0.21	2.14	5.41	0.24	3.44
7	128.5	2.109	0.63	0.77	0.92	2.03	0.12	1.26	2.91	0.13	2.27

8	256.5	2.409	0.17	-	0.62	1.11	-	0.68	1.44	-	1.34
9	512.5	2.710	-	-	0.38	0.56	-	-	0.61	-	0.70
10	1024.5	3.011	-	-	-	-	-	-	-	-	-
11	∞	∞	-	-	-	-	-	-	-	-	-

Clase	**L_{up}**	**$Log_{10}L_{up}$**	χ^2								
			AGROMYZINAE			**PHYTOMYZINAE**			**TOTAL**		
			TB	**FR**	**TRV**	**TB**	**FR**	**TRV**	**TB**	**FR**	**TRV**
	0.5	-0.301	0.04	6.32	0.1	0.72	30.07	0.03	0.22	64.23	0.09
1	2.5	0.398	2.17	0.02	0.08	0.34	0.55	0.11	0.28	2.37	0.02
2	4.5	0.653	1.26	1.33	0.17	2.16	4.77	0.36	2.97	4.25	0.11
3	8.5	0.929	0.17	0.12	0.094	0.47	9.58	3.61	0.01	17.75	2.02
4	16.5	1.217	0.56	1.77	1.51	1.87	0.39	0.35	0.32	0.41	0.05
5	32.5	1.512	0.29	0.03	0.46	0.11	0.21	0.61	0.03	2.44	1.31
6	64.5	1.810	0.22	1.01	1.26	0.47	29.73	0.43	0.41	27.38	0.33
7	128.5	2.109	4.05	0.77	0.62	1.11	-	2.53	0.13	-	0.13
8	256.5	2.409	-	-	0.99	0.35	-	-	0.25	-	-
9	512.5	2.710	-	-	-	-	-	-	-	-	-
10	1024.5	3.011	-	-	-	-	-	-	-	-	-
11	∞	∞	-	-	-	-	-	-	-	-	-

	AGROMYZINAE			**PHYTOMYZINAE**			**TOTAL**		
	TB	**FR**	**TRV**	**TB**	**FR**	**TRV**	**TB**	**FR**	**TRV**
$\sum \chi^2$	8.77	11.35	5.29	7.59	75.30	8.03	4.63	118.83	4.12
d.g	5	5	6	6	4	5	6	4	6
$Table\ \chi^2$	P=0.05 11.07	P=0.05 11.07	P=0.05 12.59	P=0.05 12.59	P=0.05 9.49	P=0.05 11.07	P=0.05 12.59	P=0.05 9.49	P=0.05 12.59
Significance	No	Yes	No	No	Yes	No	No	Yes	No

Table 5-11. Summary of adjusted calculation of captures at logarithmic normal series model. It shows the expected number of species, the calculated χ^2 and the degree of significance.

In an attempt to fit the data captures to the broken stick model or random niche boundary we have seen the impossibility of its setting. This model is the realistic expression of a uniform expression. It is a model which is heavily influenced by sample size (COHEN, 1968; POOLE, 1974). However, an adjustment to a broken stick model shows evidence of an important ecological factor that is more or less uniformly shared among species (MAY, 1974).

As was mentioned above, in cases where there are no species with a strong dominance one observes that the capture trends are in line with an exponential distribution. In which more abundant species would exists than others based on the existence of favorable climatic and ecological conditions. Normally the number of dominant species is less than 5, and the species abundance is reflected in captures which have patterns with exponential trends.

5.6.1.3 Biodiversity indexes

Currently the most common measure of the biodiversity is by the calculation of indexes. There are indexes for measuring the species richness like Margalef and Menhinick, and others for measuring the community structure. Furthermore there can be indexes based on dominance like Simpson and Berger-Parker, or others based on equity like Shannon.

The observation of the indexes that incorporate information on the proportional abundance of species (e.g. Shannon, Simpson and Berger-Parker) reveal significant differences between parks. The Natural Park of "Tinença de Benifassà" presents a biodiversity indexes in the range of about double in respect of the other two parks (Table 5-12). The parks of "Font Roja" and "Lagunas de La Mata-Torrevieja" reflect an abundance of biodiversity very similar to both Agromyzinae and Phytomyzinae subfamilies, although the richness of species is somewhat higher in "Font Roja".

α	AGROMYZINAE			PHYTOMYZINAE			TOTAL AGROMYZIDAE		
	TB	FR	TRV	TB	FR	TRV	TB	FR	TRV
(A) Diversity									
Species richness (S)	28	10	12	61	28	26	89	38	38
Individuals (N)	443	74	613	1083	264	639	1526	338	1252
Margalef	4.43	2.09	1,71	8.44	4.85	3.72	12.01	6.35	5.19
Menhinick	1.33	1.16	0.48	1.82	1.72	0.99	2.47	2.07	1.07
Berger-Parker (N_∞)	3.37	1.51	1.95	3.85	2.47	3.55	5.43	3.16	3.97
Simpson	0.86	0.53	0.68	0.90	0.73	0.85	0.75	0.26	0.53
Shannon	2.39	1.18	1.53	2.90	1.87	2.26	5.29	3.05	3.79
Log serie index (α)	6.65	3.12	2.15	8.95	7.74	5.48	20.88	10.99	7.56
Log normal index (λ)	52.02	12.27	14.19	89.24	31.95	34.79	130.3	38.74	48.1
(B) Adjustment models									
Logarithmic series	Si	Si	Si	No	No	Si	Si	No	No
Normal logarithmic	Si	No	Si	Si	No	Si	Si	No	Si
Broken stick	No	No	No	No	No	No	No	No	No

Table 5-12. Indexes of alpha biodiversity for each of the Natural Parks studied.

The results of the indexes that indicate the dominance of species (Simpson and Berger-Parker) show that "Tinença de Benifassà" has more pronounced rates because of the strong dominance of certain species like *Ophiomyia beckeri*, *Agromyza bromi*, *Melanagromyza albocilia*, *Liriomyza Brassicae* and *Liriomyza bryoniae*. Las "Lagunas de La Mata-Torrevieja" shows a greater dominance of species than "Font Roja" by the presence of species such as *Pseudonapomyza atratula* and several species belonging to the genera *Agromyza* and *Liriomyza*. The Tinença of Benifassà has been shown as the Natural Park with greater uniformity of species (Shannon index) (5.29), followed by the "Lagunas de La Mata-Torrevieja" (3.79) and "Font Roja" (3.05). This is because the dominance present in "Tinença de Benifassà" is offset by the registration of a greater abundance of species.

5.6.2 Beta biodiversity study

The measurement of beta diversity is based on proportions between the communities studied (MAGURRAN, 1988). These proportions can be evaluated based on indexes or coefficients of similarity, dissimilarity or distance between the samples from qualitative data (presence-absence of species) or quantitative (proportional abundance of each species measured like number of individuals, biomass, density, coverage, etc.), or beta diversity indexes (WILSON & SHMIDA, 1984, MAGURRAN, 1988).

In Figure 5-119 the indexes used to characterize the beta biodiversity from ecological communities studied are summarized. To compare the distribution of specific communities the Jaccard similarity index and Sorenson have been used, being the most widely used in such studies (SOUTHWOOD, 1978; JANSON & VEGELIUS, 1981). The simplicity of analysis are presented as advantages, but have the disadvantage is that all species have the same weight in the equation, independent of whether they are abundant or rare. This consideration was conducted using the measurements of similarity based on quantitative data (SOUTHWOOD, 1978), normally applying the Sorenson index modified by BRAY & CURTIS (1957); or, Morisita-Horn. Moreover, the Whittaker index of species replacement was applied and the complementarity between species was studied. The latter measures the degree of difference in species composition between different communities.

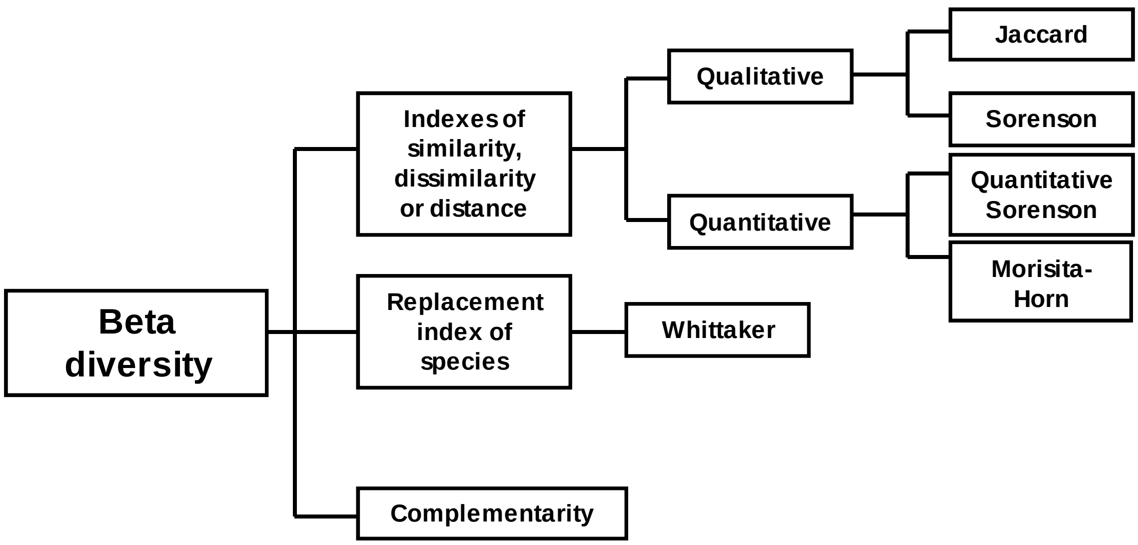

Figure 5-119. Schematic diagram of indices and models used to estimate the beta biodiversity in each of the naturals parks studied.

Table 5-13 Mathematically summarizes the indices used in the measurement of beta diversity. It is noted that the complexity of calculating of the indexes is much higher in the case of using quantitative data.

Jaccard $$C_J = \frac{j}{a+b-j}$$

j: shared species; a, b: richness in sites.

Sorenson $$C_S = \frac{2j}{a+b}$$

Sorenson quantitative $$C_N = \frac{2jN}{(aN+bN)}$$

aN is the total number of individuals in the locality A, bN the total number of individuals in the locality B, and jN the sum of the abundances of species less represented found in both locations.

Morisita-Horn $$C_{MH} = \frac{2\sum(an_i \times bn_i)}{(da+db)\,aN \times bN}\ ;\ da = \frac{\sum an_i^2}{aN^2};\ db = \frac{\sum bn_i^2}{bN^2}$$

an_i, bn_i, number of individuals of the i-th species in the locality A and B, respectively.

Whittaker index $$\beta = \frac{S}{\alpha - 1}$$

α = Average number of species in samples

Complementarity $$C = \frac{S_A + S_B - 2V_{AB}}{S_A + S_B - V_{AB}} \times 100$$

S_A y S_B = species richness of communities A and B

V_{AB} = number of species in common between two communities

so that,

$$C = \frac{exclusive\ species\ from\ a\ site}{total\ richness\ for\ both\ sites\ combined} \times 100$$

Table 5-13. Summary of mathematical formulas that characterize each one of the indexes and mathematical models used to estimate the beta biodiversity.

Using the Shannon diversity index it is possible to compare the differences in diversity between locations (PEET, 1974). The uniformity among the localities studied can be calculated using the formula, $E = H'/\ln S$ (PIELOU, 1969), being "$\ln S$" the maximum biodiversity. The variation of the observed biodiversity can be calculated using $Var\,H' = (\sum p_i(\ln p_i)^2 - (\sum p_i \ln p_i)^2)/((S-1)/2N^2)$. A t-test allows us to compare the diversity of the localities $t = (H'_1 - H'_2)/(Var\,H'_1 + Var\,H'_2)^{1/2}$. Finally, the degrees of freedom are $df = (Var\,H'_1 + Var\,H'_2)^2 / \left[(Var\,H'_1)^2/N_1\right] + \left[(Var\,H'_2)^2/N_2\right]$. The t-student table reveals the existence of significant differences between the diversity present in the localities studied.

	AGROMYZINAE			PHYTOMYZINAE			TOTAL		
	TB	**FR**	**TRV**	**TB**	**FR**	**TRV**	**TB**	**FR**	**TRV**
Uniformity E	0.72	0.51	0.62	0.71	0.56	0.70	1.18	0.84	1.05

	AGROMYZINAE			PHYTOMYZINAE			TOTAL		
	TB-FR	**TB-FR**	**TRV-FR**	**TB-FR**	**TB-FR**	**TRV-FR**	**TB-FR**	**TB-FR**	**TRV-FR**
t **calculated**	5.31	5.93	1.72	6.06	4.74	2.29	12.04	11.15	4.22
d.f	148	718	96	531	1599	519	693	2744	561
Significance P<0.05	SI	SI	NO	SI	SI	SI	SI	SI	SI
Significance P<0.001	SI	SI	NO	SI	SI	NO	SI	SI	SI

Table 5-14. Uniformity of species abundance and degree of significance between Natural Parks studied using a modification of Shannon index indicator of the equity of captures in α biodiversity.

E can take values between 0 and 1, where 1 represents a situation in which all species are equally abundant. The significant differences between parks show that they are very different taking into account the use of the Shannon index for comparing two different study sites. The abundance of diversity observed within the Agromyzinae family has not been significant when comparing the parks of the "Lagunas de La Mata-Torrevieja" and "Font Roja", but there have been significant differences comparing the Phytomyzinae subfamily and overall captures. We can conclude that the abundances in the captures are different between parks, introducing a greater degree of uniformity when comparing the parks mentioned above. It is evident that the Natural Park of "Tinença de Benifassà" is the richest in biodiversity species, in which more species are captured which are new to science.

To compare the species complementarity with the Whittaker index (β), this has been modified as follows $\beta = \left(\frac{a_t}{\bar{a}} - 1\right) \times 100$, where a_t is the cumulative total number of species in the compared localities, and $\bar{a}$ the average number of species.

Table 5-15 shows the overall indexes calculated between the different localities studied. By comparing pairs of samples, the complementarity and beta diversity have a minimum value of zero if the two communities are identical and a maximum value of 100 when the communities are completely different. This is not the case when it comes to more than two samples. It is noted that the extent of the observed complementarity between parks shows that parks are very different from one another. The greatest differences were obtained between captures of Agromyzinae from the natural parks of “Font Roja” and “Lagunas de La Mata-Torrevieja” with a value of 90%. Total captures have similar complementarities between parks close to 80%, which indicates the presence of a large number of different and endemic species into each area as the uniformity E indicates. Especially common is the existence of new species not yet described because the Agromyzidae family in Spain and most regions of Europe isn’t studied at any great depth.

β	**AGROMYZINAE**			**PHYTOMYZINAE**			**TOTAL AGROMYZIDAE**		
	TB-FR	**TB-TRV**	**FR-TRV**	**TB-FR**	**TB-TRV**	**FR-TRV**	**TB-FR**	**TB-TRV**	**FR-TRV**
C_J	0.23	0.21	0.10	0.26	0.21	0.23	0.25	0.21	0.19
C_S	0.37	0.35	0.18	0.41	0.35	0.38	0.40	0.35	0.32
C_N	0.23	0.14	0.14	0.06	0.17	0.07	0.11	0.16	0.10
C_{MH}	0.44	0.95	0.40	0.73	0.26	0.30	0.60	0.38	0.30
β	63.16	65.00	81.81	59.09	64.71	62.26	60.32	64.80	68.00
C (%)	77.4	78.79	90	74.29	78.57	76.74	75.25	78.64	80.95

Table 5-15. Beta biodiversity indexes for each of the Natural Parks studied. TB= “Tinença de Benifassà”, FR= “Font Roja” and TRV= “Lagunas de La Mata-Torrevieja”.

In general, the qualitative measurement of the beta diversity was low, which is consistent with the complementarity index obtained. The qualitative indexes obtained show very different faunal compositions that reflect the great ecological differences of each place. Quantitatively the index that best reflects the differences found in the captures is Morisita-Horn. It is noted globally that the Natural Park of “Tinença de Benifassà” has nearly double the amount of species found in the other two parks. Higher rates are present when compared with the Natural Park of “Font Roja”, except in the Agromyzinae subfamily. Whereas all comparisons with the park of the “Lagunas de La Mata-Torrevieja” show the lowest indexes, reflecting the existence of much lower abundances.

5.6.3 Gamma biodiversity study

The measurement of the gamma diversity allows us to accurately estimate the extent to which the global richness of a community is due to a kind of community (even for a single community) very rich in species, or in contrast due to the presence of a strong number of different species in different communities (high complementarity).

SCHLUTER & RICKLEFS (1993) propose the measurement of the gamma diversity based on the components alpha, beta and the spatial dimension (Table 5-16). In this way, the value of obtained gamma diversity is expressed in number of species and considers the biological elements originally analyzed by WHITTAKER (1972). Its value tends to approach the total number of species in the landscape, obtained simply by adding the different species in all communities.

In view of the results shown in Table 5-17 the gamma diversity index obtained is much lower than the total number of species captured globally in the three parks studied. This means that only 79 species are interrelated, which indicate a high percentage of species unique to each place. It is noted that this occurs for species belonging to both of the subfamilies, Agromyzinae and Phytomyzinae. The highest degree of decompensation is observed due to the rich biodiversity contained in the Natural Park of "Tinença de Benifassà" compared with the other 2 parks. It is normal that by comparing the biodiversity between different Natural Parks a low complementarity of species and a high proportion of species unique to each location is observed.

$$\boxed{\gamma\, diversity = \alpha\; average\, diversity \times \beta\; diversity \times sample\, size}$$

$\alpha\ average =$ average number of species in a community.

$\beta\ diversity =$ inverse of the specific dimension, ie average 1/average number of communities occupied by a species.

$sample\ size =$ total number of communities.

Table 5-16. Formula used for calculating the gamma biodiversity in the three Natural Parks studied.

γ	AGROMYZINAE	PHYTOMYZINAE	TOTAL AGROMYZIDAE
	TB-FR-TRV	TB-FR-TRV	TB-FR-TRV
$\alpha\ average$	16.7	38.3	55
$\beta\ diversity$	0.2418	0.2271	0.4795
$\gamma\ diversity$	12.1	26.1	79.1

Table 5-17. Gamma biodiversity indexes for each of the Natural Parks studied. TB= "Tinença de Benifassà", FR= "Font Roja" and TRV= "Lagunas de La Mata-Torrevieja".

Ecological study of Agromyzidae 6

6.1 Agromyzidae preference for their host-plants

6.1.1 Agromyzidae-plant specificity

The high specificity between plants and the family Agromyzidae is known because they are an exclusively phytophagous species, so that they attack certain plant organ and tissues (topospecificity) in a certain definite way (leafs, cambium, stem pith, stem basis, roots or on the hypanthium in fruits or seeds). The mode of nutrition is used as a criterion to classify and discriminate species within Agromyzidae.

The high specificity is due to the existence of a high degree of specialization within the family. The predominant behaviours are the monophagy and the oligophagy (BRUES, 1946).

In the literature there is some confusion about defining specifically what monophagy and oligophagy are, due to the existence of certain cases which require different approaches. In general the strict monophagy is one that corresponds to the specificity on a single host plant (TEMPERE, 1946 and HEIKERTINGER, 1931). For this reason defining is complicated in some cases as Agromyzidae in which a high level of genera specialization has been observed. That is why it is distinguished between monophagy of the first degree (strict monophagy), monophagy of second degree (a particular phytophagous species feeding on a single plant section or subgenus) and monophagy of the third degree (a particular phytophagous species feeding on a single plant genus) (HERING, 1951). In the same sense, we distinguish between systematic oligophagy (a particular phytophagous species feeding on related plants) and disjunctive oligophagy (a particular phytophagous species feeding on a relatively small number of unrelated plants) (VOIGHT, 1932). These two kinds of oligophagy together form a combined oligophagy: the first degree means a phytophagous species feeding on representatives of various plant genera belonging to the same family, the second that on representatives of various plant families of the same order, and the third that on those of a number of different but related plant orders (HERING, 1951).

Among the Agromyzidae monophagy of the second and that of the third degree are most common, systematic oligophagy of the first degree being frequent to species feeding on a number of closely related plant genera and on a few more unusual cases on a plant tribe, on a plant subfamily or in the whole family.

In the Agromyzidae there is no proper disjunctive oligophagy, however, three cases of combined oligophagy are known to occur here. As exemple NOWAKOWSKI (1962) cites *Agromyza reptans* Fallén, 1823, a common miner of *Urtica* L., feeds on other Urticaceae too: on *Parietaria* L. and *Laportea* L., as well as on Cannabaceae: on *Cannabis sativa* L., C. gigantea hort. and *Humulus japonica* Sieb. and Zucc. (BUHR, 1937, 1954).

The close relationship between the high specificity of Agromyzidae and phytochemical compounds is found in plants. The introduction to the work of SPENCER (1990) outlines the need to address a correlation study of Agromyzidae with their host-plants based on their phytochemical composition. Many cases of oligophagy are produced by this factor, but in other cases the existing low affinity suggests a lower degree of specialization or a greater similarity in the physical shape and consistency of the material mined.

Within the poliphagy two possibilities can be distinguished: the occurrence of a phytophagous species on its specific host-plants (euphagy), and the exceptional occurrence of a phytophagous species on a non-specific host-plant termed as secondary substratum (xenophagy). Xenophagy in its strict sense applies merely to cases in which a non-specific host-plant is neither related to the specific one nor similar to it phytochemically.

HERING (1951) explains that the errors in the nature of laying eggs in plants has little relation because their phytochemical composition has been key to the development of some cases of oligophagy and in other cases to the great polyphagy observed in some species.

6.1.2 Factors involved in the selection of the host

The choice of a plant by a phytophagous insect depends on their ability to break the direct resistance exerted by the plant, and the resistance exerted by secondary environmental factors. In this sense, the physiological status of the plant is vital at the moment of infestation. This physiological state is determined by the "lifestyle" of the plant, as well as the secondary factors exerted by the environment to which the plant is wrapped.

An agromyzid species may avoid certain plant species or genera within a larger systematic group of its hosts, or it may occur exclusively on plant species or genera that are not directly related. There is no doubt, that the influence exerted by many secondary factors modifies that of the phylogenetic relationship of the host-plants.

Oligophagy in the broad sense is explained by phytochemical similarities of the selected plant species as well as of the invaded organs and tissues, certain authors pay more attention to “nutritional” (e.g. specific proteins by HERING, 1926, 1951) substances while others to “attractive” (e.g. FRAENKEL, 1953) substances. The theory in which the majority of authors are supported is that the selection of the host is due to substances that provide the attraction for miner such as glucosides, essential oils, alkaloids, sapponines or tannings. Inducing an attactive or repulsive effect on phytophagous insects these substances define the host plant specificity. It is considered that the attraction factor is not only olfactory because when the females go to make oviposition they carry out numerous food punctures contacting the ovipositor and the proboscis with the sap of the plant (HENDEL, 1931; SÉLLIER 1947; CIAMPOLINI, 1952).

The geographical factors determine the distribution of plants, and in this sense the miners are affected in the same way. Surrounding areas often have a similar flora in which phytophagous insects can spread and develop.

Another factor to consider is the rejection of plants that are not specific to the site (allochthonic plant species), phenomenon known as Xenophobie. HERING (1952) cites *Ophiomyia maura* (Meigen, 1838) as an example living in Europe on *Solidago virgaurea* L. and *Aster amellus* L. and in Japan also on *Eringeron annuus* L. (SASAKAWA, 1953), avoids *Solidago canadiensis* L. and *S. serotina* Ait. of North American origin, now common in Europe. The same phenomenon can occur with the autochthonic plants of the site. The opposite to xenophoby is the xenophily for example favouring the allochthonic plants.

A considerable influence on the plant choice by the insects in question is also exerted by certain morphological and anatomical features on the invaded plant organs, thus, firstly in the leaves. This influence is revealed, when the same insect species feeds exclusively on plants with similar leaves but which are not considered as directly related, owing to certain differences in the generative organs, or when an insect species avoids a plant species of a leaf structure not typical for the group of its host plants. The resemblance of the leaf shape as such must be of little importance to phytophagous insects, it may, however, be correlated with certain phytochemical and physiological similarities more essential of them.

What can be observed in most cases is hard and stiff leaves containing many cells with thickened and sclerotized membranes as well as scalelike or tiny leaves are avoided. This results, in firstly, from the preference of phytophagous dipterous larvae for soft tissues resembling humid and mouldering plant parts that their saprophagous ancestors lived in. Such inclinations have been due to the structure of the maggot: its chin cuticle, the lack of a head capsule and the rather weak mouth armature. In hard leaves a considerable resistance of plant tissue is overcome by the larva, while in tiny leaves it runs the risk of being dried up; a tiny leaf, after all, usually does not supply food in a sufficient quantity for the full development of the larva. These circumstances seem to be expressed in the attitude of the Agromyzidae towards large groups of green land plants. These insects live on Angiosperms and ferns and on liver mosses (Hepaticae) with a leaf-shaped thallus. Conifers, with hard and needle-like leaves, as well as club mosses and mosses with scaly and tiny leaves, are avoided. Among the Angiosperms which are the main group of hosts of the Agromyzidae many xeromorphic plants with cutinized, needle-like or bristle-shaped leaves, are avoided.

The preference of dipterous larvae for soft tissues partly explains their preference for herbaceous plants and dislike for xylophytes, the leaves of which are rather stiff and hard, while their stems are sclerotized and covered with a secondary cortex.

Another factor to taka into account is the structure of the organs of the attacked plant, especially the leaves. The dependence on the growth form causes a nearly one stratum vertical distribution of the mining flies. This is intensified by the fact that most Agromyzid species mining tree leaves avoid young twigs in the higher crown stratum invading but young trees and lateral shoots or lower twigs of the crowns at most.

The predilection of mining flies for the herbaceous vegetation stratum (in the forest undergrowth), their scanty occurrence in the shrub stratum and their great rarity in the tree crown stratum, thus results not merely from the inclination to soft plant tissues but also from certain other biotic characters of these tiny insects, such as hygrophily, liking for shadow, flight near the ground and pupation in the soil. These inclinations result in certain dependence of the host-plant choice also on the ecological character of the plants, consisting mainly in some preference for hygrophytes and mesophytes rather than xerophytes. In the same sense, numerous plants having not too hard and not too tiny leaves living in dry habitats are hosts of Agromyzidae and, on the other, the flies avoid the majority of hard or tiny leafed plants in humid habitats.

6.1.3 Distribution of the Agromyzidae on the vegetation

Taking into account the specificity of Agromyzidae by their host-plants and which are the main factors that influence the selection of the host one can imagine what would be the most suitable habitat for the miners.

The trophic status of the soil determines the level of nutrients that is contributed to the plant, and therefore to its growth. In this sense we can find very rich eutrophic soils with a great flora biodiversity, and the oligotrophic soils that are poor and in which less vegetation is developed, primarily xeromorphic plants.

Very wet habitats favour the development of gross plants which Agromyzidae finds difficult to attack. Also the existence of a sheet of water on the soil surface makes pupation and adult development difficult.

Due to dampness, shadow and protection from winds a forest must be, as a rule, a more favourable habitat than is the case with open spaces, but it is only so when the herbaceous vegetation stratum is well developed. A higher percentage of arboreous plants in the flora and vegetation impoverishes the fauna of mining flies.

In reference to the forest habitat that would be ideal for Agromyzidae includes eutrophic soils very humid, shadowy, rich in floristic composition with high and thick ground covering consisting of hygrophytes and mesophytes close to river floods. Thus, the adecuate forests for a rich biodiversity of Agromyzidae are willow-poplar forests and oak-hornbeam forests. In the opposite case the poorer formations of Agromyzidae are mixed pine-oak forest, the typical pine forest and the swampy pine forests.

Mediterranean vegetation is characterized by a high percentage of arboreous plants and preponderance of evergreen plants, with cutinized or tiny leaves often even transformed into thorns or reduced altogether. That is why, as far as the Mediterranean flora is concerned, the fauna of mining flies is poor.

6.1.4 Connection between dietary specialization and speciation

Among the agromyzid species prevails monophagy of the second and third degrees, rather restricted systematic oligophagy of the first degree also being frequent, wide systematic oligophagy on the first, second and third degrees seems to prevail among the natural genera.

Restriction of the range of specific host-plants, known as “food specialization” in the case of phytophagous insects, is a kind of physiological and ecological specialization which, as in the case of morphological specialization, we recognize the chief trend of evolution, as one of its fundamental “principles”. That is why the majority of authors believe that monophagy is secondary to polyphagy and that monophagy has developed from polyphagy via oligophagy (PETERSEN, 1930; BRUES, 1946; ALLEE, 1949; HERING, 1951). At the same time, these authors assume the shifting of phytophagous insects to secondary host-plants (widening the host range) which is in accordance with the general biological principle an extension of living space. The result of this expansion is a certain temporary despecialization, some extension of the ecological niche, passing from monophagy to oligophagy or even to polyphagy. Some extension of the host range, however, in turn causes differentiation of new parasitic species, hence the expansion brings a secondary specialization and narrowing of the ecological niche. Phytophagous species have a certain ability to expand to new host-plants but, at the same time, tend towards monophagy. Monophagy is advantageous for the species, because it ensures a more stable equilibrium through uniformity of the ecological niche (PETERSEN, 1930). Thus, specialization and despecialization are two opposing tendencies gaining alternative preponderance in the course of evolution, however in the end the process of specialization prevails.

Divergency of morphological characters is clearly linked to ecological, ethological and physiological adaptation to different host plants known as food specialization.

Recent studies cited by WINKLER & MITTER (2008) have shown that insect groups (such as agromyzids and aphids) whose chief diversity is associated with modern herbaceous plants in temperate regions might well have diversified in parallel with the great Tertiary expansion of open habitats and herbaceous vegetation, driven by global cooling, drying, and latitudinal climate stratification trends (BEHRENSMEYER *et al.*, 1992; GRAHAM, 1999). This postulate shares some elements with escape and radiation coevolution (EHRLICH & RAVEN’S, 1964), including the ascription of diversification to ecological opportunity, and the distribution of insect lineages across plants to long-term historical trends. The hypothesis predicts that phylogenies of these herbivores should exhibit trends towards use of successively younger host groups, and subclade ages should roughly match those of their hosts and/or biomes (DIETRICH, 1999; von DOHLEN & MORAN, 2000; von DOHLEN *et al.*, 2006).

6.2 Biological aspects

6.2.1 Life cycle

The development cycle of Agromyzidae is shown in Figure 6-1, and includes the stages of egg, larva, pupa and adult. The egg state is short of time and hatching occurs within a few days usually favored by the warm temperatures. The young larva spends a minimum of 10 days in this state until pupa. Overwintering in larva state is unusual but occurs in some stem-borers and it is common in the holly leaf-miner *Phytomyza ilicis* Curtis, 1846 (SPENCER, 1973).

The pupa state usually lasts 10-20 days on the generation of early summer, but in species with a single generation or with a further presence in autumn this process is extended to 6-9 months.

In most species the larva becomes pupa immediately after they exit the mine and drop onto the ground or litter. In some cases the puparium is glued to the bottom of the galleries without falling to the ground, in other cases the pupation takes place inside the galleries.

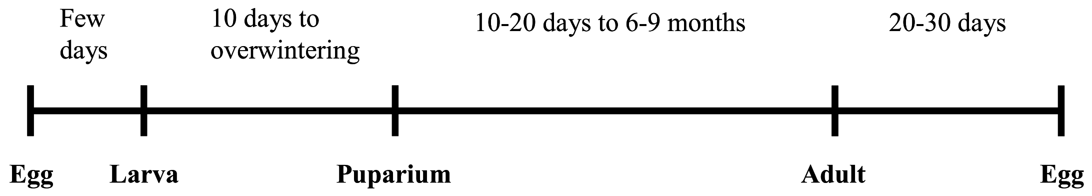

Figure 6-1. Life cycle of the Agromyzidae family.

6.2.2 Phenology

The phenology of Agromyzidae, like virtually all of the order Diptera, is greatly influenced by climatic conditions. In this way the high temperatures registered in certain places in summer, cold winter, photoperiod, etc. affect the hormonal cycle of flies making that the phenology not always correspond to a specific pattern corresponding to its own genetic nature.

It is clear that certain biological aspects of Agromyzidae are standardized. Mination and reproduction occur in a more pronounced way in the spring months, while the dormancy occurs mainly in winter. In most cases this asynchronicity is due to the diapause itself by the photoperiod-associated changes in temperature.

Other factors to take into account in the seasonality of generations include the non-diapause dormancy (e.g. quiescence), the rates of development, the number of generations per year (voltinism) and the acquisition of cold hardiness. These combined phenomena contribute to the phenology of general insects in relation to changes of biotic and abiotic environment.

Diapause and quiescence differ in that the quiescence is a cessation of the development as a direct connection to adverse environmental conditions such as low temperature or desiccation, with return to normal cycle when unfavorable conditions cease; while the diapause is regulated by the seasonality itself due to environmental signals, principally short day photoperiods that interact with an internal biological block to the endocrine regulation of development, metamorphosis or reproduction.

All these phenomena makes that the insect populations fluctuate, being a primary factor in the case of the family Agromyzidae the presence of host-plants on which they can develop.

This thesis develops the phenological patterns of behaviour for most species and genera captured. Furthermore, it has been established the main relations of bio-ecological behaviour of *Pseudonapomyza* for certain environmental patterns such as temperature and precipitation.

6.2.3 Natural enemies

Tritrophic relations consider the inclusion of natural enemies. As already mentioned in the introductory chapters the parasitoids of Agromyzidae are the Braconids, Chalcids and Cynipids.

The Braconidae family belongs to Hymenoptera order, Apocrita suborder and Ichneumonoidea Superfamily. It is divided into 33 subfamilies of which Alysiinae and Opiinae affect the Agromyzidae family.

Braconids often parasitize the host larvae introducing an egg in them through the ovipositor. Later, the parasitic larva feeds into the host larva, until the emergence of parasitoids by means of the puparium. Among Braconidae there is not authentic parasitoids of eggs; the Cheloninae, Ichneutinae and a few species of other groups oviposite inside the egg host but their larval development occurs in the larval state of hosts.

Within Alysiinae, the tribes Dacnusini and Alysiini show a greater preference for Agromyzidae. Dacnusines are confined almost exclusively to leaf and stem-mining Agromyzidae, Ephydridae and Chloropidae; while Alysiini use a wide variety of Cyclorraphus hosts, often in moist habitats and decaying ephemeral substrates, including families such as Phoridae and Drosophilidae (WHARTON *et al.*, 1997).

The Opiinae are essentially dipterous parasitoids of the families Agromyzidae y Tephritidae. Although at least 13 other families of Diptera have been recorded as hosts of Opiinae (FISCHER, 1971) such as Trypetidae, Drosophilidae and Anthomyiidae.

From the viewpoint of biological control are numerous the studies that have been made with parasites belonging to these two subfamilies, Alysiinae and Opiinae, of which some examples are BURGIO, *et al.* (2007), HOSSAIN & POEHLING (2006b), BADER *et al.* (2006) and ABD-RABOU, S. (2006).

The most prominent publications in Spain in relation to families Opiinae and Alysiinae are made by AVINENT (1987), AVINENT *et al.* (1988), BENAVENT-CORAI *et al.* (2005b), DOCAVO (1955, 1960, 1962, 1965, 1967 and 1985), DOCAVO *et al.* (1985a, 1985b, 1987a, 1987b), FALCÓ-GARÍ (2006), FISCHER (1971, 1972, 1977, 2004, 2005), FISCHER *et al.* (2002, 2004) FRANCÉS (1988), FRANCÉS & JIMÉNEZ (1989a, 1989b, 1989c), JIMÉNEZ (1980, 1983a, 1983b), JIMÉNEZ *et al.* (1992), PARDO *et al.* (2000, 2001), JIMÉNEZ & TORMOS (1987, 1988, 1990), SÁIZ (1976), TORMOS (1986) and TORMOS *et al.* (2003).

The Chalcididae belongs to the Apocrita suborder and Chalcidoidea superfamily. The most important subfamilies of parasites for Agromyzidae are Eulophidae and Pteromalidae.

Pteromalidae is a heterogeneous family able to parasitize different orders of insects such as lepidopterans, beetles, dipterans and hymenopterans with much less relevance than the family Eulophidae.

Eulophidae family consists of 5 subfamilies: Elachertinae, Eulophinae, Entedoninae, Eudarinae and Tetrastichinae. Except Entedoninae that consists of endoparasite species of eggs, larvae and pupae of beetles, the remaining subfamilies are important in the parasitism of Agromyzidae like endo- and ectoparasites basically of larvae.

Among the species used in biological control emphasizes *Diglypus isaea* (Walker, 1838) for the control of polyphagous species as *Liriomyza trifolii* (Burgess in Comstock 1880) or *Chromatomyia horticola* (Goureau, 1851) in greenhouses (e.g. BENE, 1990 and SHA *et al.*, 2007). Between some species recently used in the last years it can be cited to *Neochrysocharis formosa* (Westwood 1833) used also for the control of *Liriomyza trifolii* (HONDO & KANDORI, 2006); *Neochrysocharis okazakii* Kamijo, 1978 used for the control of *Liriomyza chinensis* Kato, 1949 (TRAN & TAKAGI, 2006); *Cirrospilus variegatus* (Masi, 1907); *Hemiptarsenus zilahisebessi* Erdös, 1951 used in the biological control of *Liriomyza sativae* Blanchard, 1938 (HESAMI *et al.*, 2006); and others like *Cirrospilus vittatus* Walker, 1838, *Hemiptarsenus zilahisebessi*, *Diglyphus crassinervis* Erdös, 1958 and *Pnigalio pectinicornis* (Linnaeus 1758) (TALEBI *et al.*, 2005).

Within the family Fagitidae (Cynipoidea superfamily) it is cited *Gronotoma micromorpha* (Perkins, 1910) for the control of *Liriomyza trifolii* and *Liriomyza bryoniae* (Kaltenbach, 1858) in greenhouses (ABE & TAHARA, 2003; ABE & KONISHI, 2004 and ABE, 2006)

It is of crucial importance the conservation of the ecological balance between Agromyzidae and their parasitoids. Their rupture is often caused by the indiscriminate use of insecticides, being key for their conservation in the establishment of pest control measures (SPENCER, 1990).

Generally agromyzids are also susceptible to bacterial and fungal pathogens and also to nematodes (DEMPEWOLF, 2004). In this sense, other biological control agents have been developed without results totally effective. Microbial agents use (DUBEY *et al.*, 1998), radiation (SHARMA *et al.*, 1996), rice-straw mulch (HIRANO *et al.*, 1993), contaminant nematodes (CHAWLA *et al.*, 1990), and neem products (KUNDU & TRIMOHAN, 1992), have been tested by several authors. Intercropping, weed management, modify of plant density, or modify phenolic and tanin contents, are other examples.

6.3 New host-plants for Agromyzidae (Diptera) from Eastern Spain

Abstract - This study presents 34 new host-plants for Agromyzidae from a total of 153 interactions established in 94 genera belonging to 27 botanical families. The interactions were established in three Natural Parks from Eastern Spain on 27 Agromyzidae species: *Ophiomyia beckeri* (Hendel, 1923); *Ophiomyia ononidis* Spencer, 1966; *Amauromyza (Amauromyza) balcanica* (Hendel, 1931); *Amauromyza (Amauromyza) carlinae* (Hering, 1944); *Amauromyza (Amauromyza) morionella* (Zetterstedt, 1848); *Amauromyza (Cephalomyza) flavifrons* (Meigen, 1830); *Amauromyza (Cephalomyza) karli* (Hendel, 1927); *Chromatomyia horticola* (Goureau, 1851); *Chromatomyia periclymeni* (Hendel, 1922); *Liriomyza brassicae* (Riley, 1884); *Liriomyza bryoniae* (Kaltenbach, 1858); *Liriomyza cicerina* (Rondani, 1875); *Liriomyza congesta* (Becker, 1903); *Liriomyza dianthicola* (Venturi, 1949); *Liriomyza orbona* (Meigen, 1830); *Liriomyza pascuum* (Meigen, 1838); *Liriomyza strigata* (Meigen, 1830); *Liriomyza trifolii* (Burgess *in* Comstock, 1880); *Napomyza lateralis* (Fallén, 1823); *Phytomyza hellebori* Kaltenbach, 1872; *Phytomyza plantaginis* Robineau-Desvoidy, 1851; *Pseudonapomyza atratula* Zlobin, 2002; and five undetermined species belonging to genera *Liriomyza*, *Phytomyza*, and *Pseudonapomyza*. Agromyzidae damages on families and botanical genera are studied and broken down in function of botanical species and their miners.

Key words: Diptera, Agromyzidae, host-plants, new interaction, *Ophiomyia*, *Amauromyza (Amauromyza)*, *Amauromyza (Cephalomyza)*, *Chromatomyia*, *Liriomyza*, *Napomyza*, *Phytomyza*, *Pseudonapomyza*, Palaearctic, Europe, Spain.

Introduction

Agromyzidae is a strict phytophagous family of diptera. They exhibit an array of different feeding habits such as leaf-mining, stem-mining and stem-tunneling, cambium-mining, and parasitism of flower heads and fruits (DEMPEWOLF, 2004). Leaf-mining is generally the most widespread feeding behaviour among Agromyzidae. The great majority (99.4%) of the Agromyzidae species show a high degree of host specialization which makes these insects especially suitable for taxonomic-phylogenetic considerations (SPENCER, 1990).

Generally damages are detected visually in form of mines along leaves. Visual detection in stems, roots, floral heads, or fruits is more difficult. Mination reduces the photosynthetic capacity, the cambium area, the nutrient transport capacity, and the quality of commercial products (ZHANG *et al.*, 2006). Development of secondary fungal pests in the galleries is subsequently produced. Damage is variable in function of the infestation. There is a lot bibliography about the control of Agromyzidae especially in horticultural crops. The most recent systems are the use of insecticides (WU *et al.*, 2007; RAMESH & UKEY, 2007; WEINTRAUB & MUJICA, 2006; WANG *et al.*, 2006; SARADHI & PATNAIK, 2006; HOSSAIN & POEHLING, 2006a), the improvement of host varietal resistance (SHARMA *et al.*, 2007; WU *et al.*, 2006; JADHAV *et al.*, 2006), the use of parasitoids (TRAN *et al.*, 2006; TOKUMARU &

ABE, 2006; TELLEZ *et al.*, 2006; HESAMI *et al.*, 2006; YANG *et al.*, 2005), and bacteriums (TAGAMI *et al.*, 2006).

According to MARTINEZ, 2004 the number of Agromyzidae species of Spain reach 236 of 906 European species. This number is being actualized until 287 (see the chapter 5.4.1 of this thesis). It is worldwide known the ignorance of a high percentage of the Agromyzidae fauna of Spain.

On the whole 1285 Agromyzidae species are known of 146 botanical families and 899 botanical genera (BENAVENT-CORAI *et al.*, 2005). Approximately 50% of Agromyzidae have unknown hosts of a total of 2900 world distributed species. Getting to know all interactions of Agromyzidae it would be really important for establishing their ecology and phylogeny.

Detection of damaged flora and subsequent obtaining of miner species under bioclimate conditions are developed in this work. The interactions established in different natural biotops of the Mediterranean Spain are presented, showing the great possibility of Agromyzidae development on wild flora. It is possible the approximation to the knowledge of the miner species identifying the damage produced on the flora present around the crops due to the close coevolution of plants and miners. Vegetal covers management is an important cultural method for diminishing the attacks of Agromyzidae on agricultural and ornamental crops, by means of avoiding some and favouring others.

Material and methods

Sampling areas

The sampling was realized in three Natural Parks from Community of Valencia: “Tinença de Benifassà” (Castellón), “Font Roja” (Alicante) and “Lagunas de La Mata-Torrevieja” (Alicante). Areas studied were selected based on their different environmental performance.

Tinença de Benifassà.- Natural Park located in the Northern of the Community of Valencia bordering with Tarragona and Teruel provinces. It has pine and oak forests composed predominantly by *Pinus halepensis* Mill. and *Quercus ilex* L. species. Such formations are specially protected in thirteen flora microreserves. The little anthropical influence creates a particular unchanged ecosystem. Sampling altitude was around 750 m a.s.l (above sea level). The annual rainfall in this area is usually around 450-500 mm.

Font Roja.- Located between Alcoy (North-East) and Ibi (South-West). The botanical composition is formed by several landscape units composed by deciduous forests (predominantly *Quercus faginea* Lam., *Fraxinus ornus* L., *Acer opalus* Mill., *Sorbus aria* (L.) Crantz, and *Taxus baccata* L.), holm oak-groves (*Quercus ilex* L.), pinus (*Pinus halepensis* Mill.), sunny brushwoods, rock vegetation, rubble vegetation and crops. The craggy terrain inserted in a mountainous system provides high altitudes around 1000 m a.s.l. Annual precipitation is estimated around 350-450 mm.

Lagunas de La Mata-Torrevieja.- Located in the Southern of the Community of Valencia. It is characterized by salt marsh vegetation, rush plants, and scrubland. The lagoons are surrounded by the best redoubts of dry and damp salt marsh vegetation. At the Southern there are hill vegetation consisting of *Pinus halepensis* Mill. and *Quercus coccifera* L., combined with typical dry Mediterranean vegetation. Practically located over sea level, with low annual precipitations (<300 mm) and high summer temperatures (>35ºC).

GPS locations.- Into each Natural Park, different areas were sampled with a maximum of 7-10 representative points. The sampled space for each point was estimated around 100 m of radius.

Locality	Code point	GPS (38 Channels)	High
"Tinença de Benifassà"	TB1	N40º39'22.6"E00º09'26.8"	755
	TB2	N40º40'05.8"E00º08'25.9"	740
	TB3	N40º39'51.3"E00º08'30.0"	727
	TB4	N40º39'31.4"E00º07'46.5"	783
	TB5	N40º39'18.9"E00º09'08.9"	712
	TB6	N40º39'44.5"E00º10'58.5"	721
	TB7	N40º39'48.9"E00º10'21,4"	710
"Font Roja"	FR1	N38º39'43.1"W00º31'04.0"	1076
	FR2	N38º39'40.5"W00º33'09.8"	1177
	FR3	N38º39'27.0"W00º33'40.7"	1222
	FR4	N38º39'33.2"W00º32'31.4"	1299
	FR5	N38º39.49'4"W00º31'54.4"	1081
	FR6	N38º39'46.6"W00º31'32.9"	1071
	FR7	N38º39'53.9"W00º32'20.8"	1054
"Lagunas de La Mata-Torrevieja"	TRV1	N38º01'19.7"W00º40'54.2"	6
	TRV2	N38º01'35.6"W00º41'21.1"	2
	TRV3	N38º01'48.8"W00º42'00.1"	5
	TRV4	N38º01'56.6"W00º42'19.7"	4
	TRV5	N38º01'57.2"W00º42'37.9"	4
	TRV6	N38º01'56.9"W00º42'43.0"	9
	TRV7	N38º01'15.7"W00º43'49.1"	6
	TRV8	N38º01'38.8"W00º41'27.5"	5
	TRV9	N38º01'56.6"W00º42'09.4"	4
	TRV10	N38º01'57.2"W00º42'37.9"	5

Table 6-1. Table summary of GPS location from "Tinença de Benifassà", "Font Roja", and "Lagunas de La Mata-Torrevieja".

Sampling

The experiment was carried out throughout 2006-07 years. Weekly visual detection of damages produced by Agromyzidae on the vegetation was realized. Damage was observed due to the presence of mines in leaves and stems of wild plants. The sampling zones were characterized by the measurement of their coordinates (listed in Table 6-1).

Samples were captured and conserved into glass bags in refrigerated conditions. In the laboratory the mined leaves were selected and placed into glass boxes in a controlled environment chamber (25-26ºC, 65-70% RH). The samples were revised every 2 days, and the specimens obtained were preserved for study in ethyl alcohol 70º.

Agromyzidae identifications were realized by means of the morphological study of the genitalia in males, and the external characters of females. Agromyzidae species were associated with their attacked botanical species.

Terminology used in this paper
s.: sampling date. e.: miners emergency date. Each interaction cited in this article is indicated into brackets [ ]. GPS locations are according to Code point of Table 1. New genera of Host-Plants are marked in bold.

Identifications
Identifications of all Agromyzidae species and host-plants were carried out by R. GIL-ORTIZ. All Agromyzidae species were verified by the specialist M. MARTINEZ.

Results and discussion

One hundred and ten interactions Agromyzidae-plant, the distribution of miner species, the genera of host-plants attacked, and the material examined in this study are listed below. The interactions are submitted by genera, and subfamilies Agromyzinae and Phytomyzinae.

Geography distribution of Agromyzidae species is given according to MARTINEZ (2004). The genera of host-plants listed are according to BENAVENT-CORAI *et al.* (2005). Nomenclature of botanical species cited is based in MATEO & CRESPO (2003).

AGROMYZINAE

Genus *Ophiomyia* Braschnikov, 1897

Ophiomyia beckeri (Hendel, 1923)
Ophiomyia euphorbiae (Hendel, 1923)
Ophiomyia goniaea (Hendel, 1931)

D i s t r i b u t i o n
Palaearctic: Austria, Balearic Islands, Britain Islands, Canary Islands, Czech republic, Danish mainland, Germany, Ireland, Lithuania, Madeira, Poland, Sicily, Spanish mainland, Yugoslavia; Afrotropical region; Near East; North Africa; Oriental region.

G e n e r a o f H o s t – P l a n t s
Coreopsis, ***Centaurea***, *Crepis*, *Launaea*, *Leontodon*, ***Lepidium***, ***Reichardia***, *Sonchus*, ***Sysimbrium***, *Taraxacum*, ***Urospermum***.

M a t e r i e l e x a m i n e d
[1] Tinença de Benifassà: [1♂] s.22.v.2006, e.16.vi.2006, TB3, Host: ***Crepis bursifolia* L.**

[2] Tinença de Benifassà: [1♂,4♀] s.22.v.2006, e.16.vi.2006, TB5. Lagunas de La Mata-Torrevieja: [1♂,1♀] s.06.vi.2006, 1♂ e.16.vi.2006 and 1♀ e.23.vi.06, TRV3. Host: ***Reichardia picroides* (L.)** (*New interaction*)

[3] Tinença de Benifassà: [1♀] s.06.iv.2006, e.20.iv.2006, TB1. Lagunas de La Mata-Torrevieja: [1♂] s.30.iv.2006, e.16.v.2006, TRV2. [4♂,3♀] s.23.v.2006, e.09.vi.2006, TRV3. [2♂,1♀] s.16.v.2007, e.02.vi.2007, TRV10. Host: ***Sonchus tenerrimus* L.**

[4] Font Roja: [2♀] s.21.ix.2006, 1♀ e.02.ix.2006 and 1♀ e.12.ix.2006, FR4. Host: ***Centaurea rouyi* Coincy** (*New interaction*)

[5] Font Roja: [2♂,2♀] s.24.v.2006, e.21.vi.2006, FR7. [3♂] s.07.vi.2006, e.23.vi.2006, FR3. Host: ***Crepis vesicaria* L.**

[6] Font Roja: [1♂] s.07.ix.2006, e.02.x.2006. FR7. Host: ***Lepidium draba* L.** (*New interaction*)

[7] Font Roja: [2♂,1♀] s.07.vi.2006, 1♂1♀ e.23.vi.2006 and 1♂ e.29.vi.2006, FR3. [1♂] s.28.viii.2006, e.15.ix.2006; [4♀] s.07.ix.2006, 1♀ e.15.ix.2006, 1♀ e.22.ix.2006, and 2♀ e.02.x.2006, FR7. Lagunas de La Mata-Torrevieja: [1♂] s.14.iii.2006, e.05.iv.2006; [4♂,3♀] s.19.iv.2006, 4♂2♀ e.28.iv.2006 and 1♀ e.06.v.2006, TRV2. [2♀] s.30.iv.2007, e.18.v.2007, TRV10. Host: ***Sonchus oleraceus* L.**

[8] Font Roja: [1♀] s.24.v.2006, e.21.vi.2006, FR7. Host: ***Sysimbrium irio* L.** (*New interaction*)

[9] Lagunas de La Mata-Torrevieja: [1♂] s.30.iv.2006, e.31.v.2006; [4♂,2♀] s.16.v.2006, 1♂ e.02.vi.2006 and 3♂2♀ e.09.vi.2006, TRV2. [2♂,1♀] s.16.v.2006, e.02.vi.2006, TRV10. Host: ***Urospermum picroides* (L.)** (*New interaction*)

[10] Font Roja: [3♀] s.24.v.2006, 2♀ e.10.vi.2006 and 1♀ 21.vi.2006, FR3. Host: ***Taraxacum obovatum* (Willd.)**

N o t e . *Ophiomyia beckeri* (Hendel, 1923) belongs to the most primitive *Ophiomyia*, where the larvae undermine the midrib, with short offshoots into the leaf blade. Three species of *Ophiomyia*: *beckeri*, *cunctata* (Hendel, 1920), and *pulicaria* (Meigen, 1830) appear to have identical larval feeding in common with many host.

Ophiomyia ononidis Spencer, 1966

D i s t r i b u t i o n
Palaearctic: Britain Islands, Czech republic, Germany, Lithuania, Spanish mainland.

G e n e r a o f H o s t – P l a n t s
***Lotus**, Medicago, Ononis.*

M a t e r i e l e x a m i n e d.
[11] Tinença de Benifassà: [1♂] s.19.vi.2006, e.29.vi.2006, TB2. Host: ***Medicago sativa* L.**

[12] Font Roja: [1♂] s.29.vi.2006, e.10.vii.2006, FR4. Host: ***Lotus corniculatus* L.** (*New interaction*)

[13] Font Roja: [1♂,3♀] s.29.vi.2006, e.17.vii.2006, FR3. Host: ***Medicago sativa* L.**

N o t e. *Ophiomyia ononidis* is an oligophagous miner of Leguminosae. The adult closely resembles *Ophiomyia curvipalpis* (Zeterstedt, 1848), an oligophagous feeder on

Compositae, and the two cannot be separated on external characters. However, the differences between the two species are clearly reflected in the genitalia and also in larval characters, with the posterior spiracles in *O. ononidis* having 6-7 pores on each process, while *O. curvipalpis* retains the plesiomorphous state of three.

PHYTOMYZINAE

Genus ***Amauromyza*** Hendel, 1931

Amauromyza (Amauromyza) carlinae (Hering, 1944)

D i s t r i b u t i o n
Palaearctic: French mainland, Germany, Poland, Slovakia, Spanish mainland.

G e n e r a o f H o s t – p l a n t s
Carlina, Cirsium.

M a t e r i e l e x a m i n e d
[14] Font Roja: [1♂,5♀] s.19.vi.2006, e.17.vii.2006, FR2. Host: ***Cirsium vulgare* (Savi)**

N o t e. *A. (Amauromyza) carlinae* is related to *A. (Amauromyza) lamii* (Kaltenbach, 1858) and A. *(Amauromyza) leonuri* Spencer, 1971 on Lamiaceae and probably represents a switch of an ancestral species from Lamiaceae to Compositae.

Amauromyza (Amauromyza) morionella (Zetterstedt, 1848)

D i s t r i b u t i o n
Palaearctic: Britain Islands, Corsica, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Hungary, Italian mainland, Norwegian mainland, Poland, Romania, Sardinia, Sicily, Spanish mainland, Sweden, Yugoslavia.

Genera of H o s t – P l a n t s
Ballota, Marrubium.

M a t e r i e l e x a m i n e d
[15] Font Roja: [1♀] s.25.vi.2007, e.21.vii.2007 and [1♂] s. 04.vii.2007, e.30.vii.2007, FR3. Host: ***Marrubium vulgare* L.**

N o t e. A. (*Amauromyza) morionella* feeds on *Ballota* and *Marrubium*, and although not distinguishable on external characters from *A. (Amauromyza) leonuri* Spencer, 1971, the genitalia show that it belongs to a different group. It is closely related to *A. (Amauromyza) balcanica* (Hendel, 1931) known from Spain, Greece, and Iran, with *Phlomis* as its only confirmed host. The genitalia differs only in detail from A. (*Amauromyza) morionella* (Zetterstedt,1848).

Amauromyza (Cephalomyza) karli (Hendel, 1927)

D i s t r i b u t i o n
Palaearctic: Czech republic, French mainland, Germany, Hungary, Poland; Neartic region.

Genera of H o s t – P l a n t s
Chenopodium

M a t e r i e l e x a m i n e d
[16] Tinença de Benifassà: [1♂] s.19.vi.2006, e.17.vii.2006, TB3. Host: ***Chenopodium vulvaria* L.** (*New interaction*)

N o t e. This is the first cite of the host-plants for *A. (Cephalomyza) karli*. *Chenopodium* is also mined by *A. (Cephalomyza) abnormalis* (Malloch, 1913), and *A. (Cephalomyza) chenopodivora* Spencer, 1971.

Amauromyza (Cephalomyza) flavifrons (Meigen, 1830)

D i s t r i b u t i o n
Palaearctic: Albania, Belgium, Britain Islands, Corsica, Czech republic, Danish mainland, European Turkey, Finland, French mainland, Germany, Hungary, Italian mainland, Lithuania, Norwegian mainland, Poland, Romania, Sardinia, Spanish mainland, Sweden, The Netherlands; Neartic region.

Genera of H o s t – P l a n t s
Agrostemma, *Beta*, ***Catananche***, *Cerastium*, *Dianthus*, *Gypsophila*, ***Lepidium***, *Moehringia*, *Saponaria*, *Silene*, *Spinacia*, *Stellaria*, *Vaccaria*.

M a t e r i e l e x a m i n e d
[17] Font Roja: [1♂] s.12.vii.2006, e.08.viii.2006, FR3. Host: ***Catananche caerulea* L.** (*New interaction*)

[18] Font Roja: [1♂,2♀] s.07.ix.2006, e.02.x.2006, FR7. Host: ***Lepidium draba* L.** (*New interaction*)

[19] Font Roja: [1♂] s.07.vi.2006, e.23.vi.2006, FR2. Host: ***Silene conica* L.**

[20] Font Roja: [1♂] s.07.vi.2006, e.23.vi.2006, FR7. Host: ***Silene conoidea* L.**

N o t e. *A. (Cephalomyza) flavifrons* with normal hosts in the Caryophyllaceae has regularly been found also on *Beta* and *Spinacia* (Chenopodiaceae), both families in the same order Caryophyllales, their feeding can best be considered as extended oligophagy.

Genus ***Chromatomyia*** Hardy, 1849

Chromatomyia horticola (Goureau, 1851)

D i s t r i b u t i o n
Palaearctic: Austria, Azores, Belgium, Britain Islands, Canary Islands, Corsica, Czech republic, Danish mainland, European Turkey, Finland, French mainland, Germany, Greek mainland, Hungary, Ireland, Italian mainland, Lithuania, Madeira, Malta, Republic of Moldova, Norwegian mainland, Poland, Portuguese mainland, Romania, Sardinia, Sicily, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands,

Yugoslavia; Afrotropical region; East Palaearctic; Near East; Nearctic region; North Africa; Oriental region.

G e n e r a o f H o s t – P l a n t s

Adonis, Aethusa, Ageratum, Ajuga, Alliaria, Allium, Althaea, Alyssum, Amaranthus, ***Anagallis****, Anchusa, Andryala, Anethum, Anoda, Anthemis, Anthyllis, Antirrhinum, Apium, Arabidopsis, Arabis, Armoracia, Artemisia, Asperugo, Astragalus, Atriplex,* ***Avena****, Ballota, Bertorea, Beta, Bidens, Biscutella,* **Blackstonia**, *Borago, Brassica, Coincya, Bunias, Bystropogon, Caccinia, Cakile, Calepina, Campanula, Cannabis, Capsella, Capsicum, Cardamine, Carduncellus, Carduus, Carthamus, Carum,* ***Catananche****, Centaurea, Cephalaria, Cerastium, Cerinthe, Chaenorhinum, Chenopodium, Chrysanthemum, Cicer, Cineraria, Cirsium, Cissampelopsis, Cleome, Cochlearia, Collinsia, Conium, Convolvulus, Coreopsis, Coriandrum, Coringia, Coronopus, Cosmos, Cotinus, Cotula, Crambe, Crepis, Cucumis, Cucurbita, Cynara, Cynoglossum, Dahlia, Daucus, Descurainia, Diplotaxis, Dipsacus, Doronicum, Echium, Elsholtzia, Emilia, Erigeron, Erucastrum, Eryngium, Erysimum, Eschscholzia, Euphorbia, Gaillardia, Galeopsis, Galinsoga, Gazania, Gerbera, Glaucium, Glycine, Gnaphalium, Gynura, Gypsophila, Helianthus, Helichrysum, Heliotropium, Hesperis, Hibiscus, Hirschfeldia, Holcus, Humulus, Hyoscyamus, Hypochaeris, Iberis, Impatiens, Inula, Isatis, Jasione, Kitaibela, Knautia, Lactuca, Lagenaria, Lallemantia, Lamium, Lappula, Lathyrus, Launaea, Lavandula, Lavatera, Lens, Leonurus, Lepidium, Leucanthemum, Levisticum, Ligusticum, Limonium, Linaria, Linum, Lithospermum, Loasa, Lotus, Lupinus, Lycium, Lycopersicon, Lycopus, Malva,* **Mantisalca**, *Matricaria, Matthiola, Maurandya, Medicago, Melampyrum, Melilotus, Melissa, Mentha, Mimulus, Moluccella, Moricandia, Myagrum, Myosotis, Nepeta, Nicotiana, Nonea, Oenothera, Omphalodes, Origanum, Oxytropis, Palaua, Papaver, Pastinaca, Peltaria, Petroselinum, Petunia, Peucedanum, Phacelia,* **Phagnalon**, *Phaseolus, Phlox, Physalis, Phyteuma, Picris, Pisum, Plantago, Podonosma, Polygonum, Prunella, Pulmonaria, Raphanus, Reseda, Retama, Rhinanthus, Rhus, Rorippa, Rudbeckia, Ruta, Salicornia, Salvia, Satureja,* ***Scabiosa****, Scorpiurus, Scorzonera, Scrophularia, Scutellaria, Senecio,* ***Serratula****, Seseli, Silene, Sinapis, Sisymbrium, Solanum, Sonchus, Spinacia, Stachys, Stellaria, Symphytum, Tanacetum, Taraxacum, Teucrium, Thlaspi, Thunbergia, Tordylium, Torilis, Tragopogon, Trichodesma, Trifolium, Trigonella, Tropaeolum,* ***Urospermum****, Urtica, Valeriana, Valerianella, Verbascum, Verbena, Veronica, Vicia, Vigna, Viola, Withania,* ***Xeranthemum.***

M a t e r i e l e x a m i n e d

[21] Tinença de Benifassà: [1♀] s.07.vi.2007, e.21.vi.2007, FR3. Host: ***Anagallis arvensis*** **L.** (*New interaction*)

[22] Lagunas de La Mata-Torrevieja: [1♂,1♀] s.05.iv.2006, e.20.iv.2006, TRV6. Host: ***Avena byzanthina*** **C. Koch** (*New interaction*)

[23] Tinença de Benifassà: [1♂,1♀] s.27.vi.2006, e.30.vii.2006, TB3. Host: ***Blackstonia perfoliata*** **(L.)** (*New interaction*)

[24] Tinença de Benifassà: [10♂,5♀] s.06.iv.2006, e.20.iv.2006, TB1. Host: ***Carduncellus monspeliensum*** **All.**

[25] Tinença de Benifassà: [2♂,3♀] s.28.v.2007, e.09.vi.2007, TB5. Lagunas de La Mata-Torrevieja: [2♂] s.30.iv.2007, e.10.v.2007, TRV5. Host: ***Carduus pycnocephalus* L.**

[26] Font Roja: [1♀] s.14.vi.2006, e.23.vi.2006, FR2. Host: ***Catananche caerulea* L.** (*New interaction*)

[27] Font Roja: [1♀] s.11.v.2006, e.26.v.2006; [1♀] s.24.v.2006, e.10.vi.2006; [1♀] s.30.v.2007, e.16.vi.2007, FR3. Lagunas de La Mata-Torrevieja: [3♂,3♀] s.07.iii.2007, 3♂ 2♀ e.14.iii.2007 and 1♀ e.22.iii.2007, TRV3. Host: ***Centaurea aspera* L.**

[28] Font Roja: [1♀] s.24.v.2007, e.02.vi.2007, FR3. Host: ***Centaurea mariolensis* Rouy**

[29] Tinença de Benifassà: [3♂] s.15.v.2006, e.26.v.2007, TB2. Host: ***Centaurea scabiosa* L.** subsp. ***cephalariifolia* (Willk.)**

[30] Tinença de Benifassà: [1♂] s.15.v.2006, e.17.v.2007, TB3. Lagunas de La Mata-Torrevieja: s.16.v.2007, e.26.v.2007, TRV3. Host: ***Centaurea seridis* L.**

[31] Tinença de Benifassà: [4♂,6♀] s.15.v.2006, e.26.v.2006, TB6. Host: ***Centaurea triumfetti* All. subsp. *semidecurrens* (Jord.)**

[32] Lagunas de La Mata-Torrevieja: [5♂,4♀] s.14.iii.2007, 4♂3♀ e.22.iii.2007 and 1♂1♀ e.29.iii.2007; [3♂, 3♀] s.04.iv.2007, e.12.iv.2007, TRV10. Host: ***Chrysanthemum coroniarum* L.**

[33] Lagunas de La Mata-Torrevieja: [1♀] s.15.iii.2007, e.20.iv.2007, TRV2. Host: ***Convolvulus althaeoides* L.**

[34] Font Roja: [1♂,3♀] s.24.v.2007, e.02.vi.2007, FR3. Lagunas de La Mata-Torrevieja: [1♂] s.02.ii.2007, e.16.ii.2007, TRV2. Host: ***Crepis vesicaria* L.**

[35] Font Roja: [1♀] s.18.v.2006, e.15.vi.2006; [1♀] s.15.v.2007, e.26.v.2007; [1♀] s.24.v.2007, e.02.vi.2007; [1♀] s.30.v.2007, e.09.vi.2007, FR3. Host: ***Cynoglossum cheirifolium* L.**

[36] Tinença de Benifassà: [10♂,9♀] s.06.iv.2006, e.20.iv.2006, TB1. [1♂,1♀] s.25.ix.2006, e.10.x.2006, TB3. Font Roja: [1♀] s.24.v.2007, e.21.vi.2007, FR3. Lagunas de La Mata-Torrevieja: [1♂] s.09.iii.2006, e.20.iv.2006, TRV2. [1♀] s.23.iii.2006, e.20.iv.2006, TRV6. [1♀] s.21.ii.2007, e.08.iii.2007, TRV5. Host: ***Diplotaxis erucoides* L.**

[37] Tinença de Benifassà: [1♂] s.29.v.2006, e.09.vi.2006, TB5. Lagunas de La Mata-Torrevieja: [1♂] s.30.iv.2007, e.10.v.2007, TRV9. Host: ***Echium vulgare* L.**

[38] Font Roja: [1♂] s.11.v.2006, e.17.v.2006, FR2. [1♂] s.11.v.2006, e.26.v.2006, FR3. Host: ***Hirschfeldia incana* (L.)**

[39] Tinença de Benifassà: [1♂] s.04.vi.2007, e.21.vi.2007, TB2. Host: ***Knautia arvensis* (L.)**

[40] Tinença de Benifassà: [1♀] s.22.v.2006, e.16.vi.2006, TB5. Host: ***Knautia purpurea* (Vill.)**

[41] Font Roja: [15♂,16♀] s.20.iv.2006, e.26.iv.2006; [3♂] s.07.vi.2006, e.23.vi.2006; [2♂] s.14.vi.2006, e.23.vi.2006, FR7. Host: ***Lepidium draba* L.**

[42] Font Roja: [2♀] s.20.iv.2006, e.08.v.2006, FR5. [1♀] s.30.v.2006, e.16.vi.2006, FR2. Host: ***Leucanthemum gracilicaule* (Dufour)**

[43] Font Roja: [1♀] s.15.v.2007, e.26.v.2007, FR6. Host: ***Lithospermum arvense* L.**

[44] Font Roja: [3♀] s.24.v.2006, e.10.vi.2006, [1♀] s.29.ix.2006, e.10.x.2006, FR7. Host: ***Malva parviflora* L.**

[45] Font Roja: [1♂] s.24.v.2006, e.10.vi.2006; [1♂,2♀] s.14.vi.2006, e.23.vi.2006, FR2. [3♂,1♀] s.07.vi.2006, e.23.vi.2006; [1♂] s.04.vii.2007, e.30.vii.2007, FR3. Host: ***Mantisalca salmantica* (L.)** (*New interaction*)

[46] Tinença de Benifassà: [1♂,4♀] s.22.v.2006, e.09.vi.2006, TB2. [3♀] s.22.v.2006, 1♀ e.09.vi.2006 and 2♀ e.21.vi.06, TB7. Host: ***Medicago sativa* L.**

[47] Tinença de Benifassà: [1♂,1♀] s.08.v.2006, e.03.vi.2006, TB5. Lagunas de La Mata-Torrevieja: [2♀] s.14.iii.2007, e.22.iii.2007, TRV3. Host: ***Papaver rhoeas* L.**

[48] Lagunas de La Mata-Torrevieja: [2♂,1♀] s.14.iii.2007, e.22.iii.2007, TRV3. Host: ***Phagnalon saxalite* (L.)** (*New interaction*)

[49] Tinença de Benifassà: [1♂,3♀] s.25.v.2006, e.16.vi.2006, TB2. Lagunas de La Mata-Torrevieja: [1♂,1♀] s.10.v.2006, e.17.v.2006, TRV6. Host: ***Plantago lagopus* L.**

[50] Tinença de Benifassà: [2♀] s.22.v.2006, e.09.vi.2006, TB3. Host: ***Plantago lanceolata* L.**

[51] Font Roja: [1♂] s.07.vi.2006, e.16.vi.2006, FR6. Host: ***Reseda stricta* Pers.**

[52] Tinença de Benifassà: [1♂,5♀] s.19.vi.2006, e.29.vi.2006, TB2. [2♀] s.21.v.2007, 1♀ e.02.vi.2006 and 1♀ e.16.vi.2006, TB3. Host: ***Scabiosa atropurpurea* L.** (*New interaction*)

[53] Font Roja: [3♀] s.20.iv.2006, 2♀ e.26.iv.2006 and 1♀ e.08.v.2006, FR5. [5♂,5♀] s.11.v.2006, e.17.v.2006; [1♂,2♀] s.07.vi.2006, e.21.vi.2006, FR4. Host: ***Serratula pinnatifida* (Cav.)** (*New interaction*)

[54] Font Roja: [1♂,2♀] s.07.vi.2006, e.16.vi.2006, FR7. Host: ***Silene conoidea* L.**

[55] Font Roja: [2♀] s.11.v.2006, e.09.vi.2006, FR3. Host: ***Sinapis alba* L.**

[56] Tinença de Benifassà: [2♂,1♀] s.06.iv.2006, e.24.iv.2006, TB1; [1♀] s.21.v.2007, e.16.vi.2007; [1♂] s.28.v.2007, e.09.vi.2007, TB3. Lagunas de La Mata-Torrevieja: [4♂] s.15.ii.2007, e.22.ii.2007, TRV5. [2♂] s.14.iii.2007, e.22.iii.2007; [1♂,1♀] s.04.iv.2007, e.12.iv.2007, TRV3. [1♂] s.10.v.2006, e.26.v.2006, TRV6. Host: ***Sonchus oleraceus*** **L.**

[57] Tinença de Benifassà: [12♂,12♀] s.06.iv.2006, e.20.iv.2006; [1♂] s.02.x.2006, e. 12.x.2006, TB1. Lagunas de La Mata-Torrevieja: [2♂] s.24.i.2007, e.02.ii.2007; [9♂,15♀] s.21.ii.2007, e.08.iii.2007; [4♂,3♀] s.30.iv.2007, e.18.v.2007, TRV2. Host: ***Sonchus tenerrimus*** **L.**

[58] Font Roja: [1♀] s.27.iv.2006, e.08.v.2006, FR4. Host: ***Sysimbrium crassifolium*** **Cav.**

[59] Font Roja: [45♂,43♀] s.20.iv.2006, 40♂36♀ e.26.iv.2006 and 5♂7♀ e.08.v.2006; [8♂,4♀] s.24.v.2006, e.10.vi.2006, FR7. Lagunas de La Mata-Torrevieja: [3♂] s.30.iv.2007, 2♂ e.10.v.2007 and 1♂ e.26.v.2007, TRV3. Host: ***Sysimbrium irio*** **L.**

[60] Font Roja: [2♀] s.07.vi.2007, e.21.vi.2007, FR3. Host: ***Sysimbrium officinale*** **(L.)**

[61] Font Roja: [2♂,2♀] s.07.vi.2006, e.16.vi.2006; [3♂,4♀] s.24.v.2007, 2♂3♀ e.09.vi.2007 and 1♂1♀ e.18.vi.2007, FR3. Host: ***Sysimbrium orientale*** **L.**

[62] Font Roja: [1♂,5♀] s.20.iv.2006, e.02.v.2006, FR7. [2♀] s.24.v.2006, 1♀ e.10.vi.2006 and 1♀ e.21.vi.2006, FR3. Host: ***Taraxacum obovatum*** **(Willd.)**

[63] Tinença de Benifassà: [2♀] s.15.v.2006, e.26.v.2006, TB3. Host: ***Taraxacum vulgare*** **(Lam.)**

[64] Lagunas de La Mata-Torrevieja: [1♀] s.07.iii.2007, e.22.iii.2007; [1♂2♀] s.30.iv.2007, e.18.v.2007, TRV2. Host: ***Urospermum picroides*** **(L.)** (*New interaction*)

[65] Tinença de Benifassà: [2♂,2♀] s.28.v.2007, e.09.vi.2007, TB5. Host: ***Vicia sativa*** **L.**

[66] Font Roja: [1♂] s.11.v.2006, e.26.v.2006; [2♂,1♀] s.15.v.2006, e.26.v.2006, FR3. Host: ***Xeranthemum inapertum*** **(L.)** (*New interaction*)

N o t e. *Chromatomyia horticola* species appears to have dispersed naturally across temperate areas of Africa to South Africa, it is common in parts of India and has reached eastern Asia but is entirely absent from Australian and Neotropical region. It is equally, or even more widespread than *Chromatomyia syngenesiae* Hardy, 1849 on the Compositae and it has been recorded on 239 genera in 39 families. It is the most polyphagous species in the Agromyzidae, comparable only to *Liriomyza strigata* (Meigen, 1830) and *Liriomyza trifolii* (Burgess *in* Comstock, 1880).

Chromatomyia periclymeni (Hendel, 1922)
periclymeni de Meijere, 1924

D i s t r i b u t i o n
Palaearctic: Austria, Belgium, Britain Islands, Czech Republic, Danish mainland, Estonia, Finland, French mainland, Germany, Iceland, Ireland, Italian mainland, Lithuania, Norwegian mainland, Poland, Spanish mainland, Sweden, Switzerland, The Netherlands.

G e n e r a o f H o s t – P l a n t s
Lonicera, Symphoricarpos

M a t e r i e l e x a m i n e d
[67] Font Roja: [2♂,3♀] s.11.v.2006, e.17.v.2006, FR3. [1♀] s.29.vi.2006, e.08.viii.2006, FR4. Host: ***Lonicera etrusca* G. Santi**

N o t e. *Chromatomyia periclymeni* is common throughout Europe on both *Lonicera* and *Symphoricarpos*, forming an irregular blotch mine. The male genitalia of *Chromatomyia periclymeni* is characteristic of all others in the *periclymeni* group, which differs only in minor detail. The greatest differentiation between these species is in the larval feeding instinct and thus in the form of the mine they produce.

Genus ***Liriomyza*** Mik, 1894

Liriomyza brassicae (Riley, 1884)
cruciferarum Hering, 1927
mitis (Curran, 1931)
hawaiiensis Frick, 1952
bulnesiae Spencer, 1963
ornephila Garg, 1971

D i s t r i b u t i o n
Palaearctic: Canary Islands, Corsica, European Turkey, French mainland, Germany, Romania, Spanish mainland, Afrotropical region, Australian region, East Palaearctic, Near East; Nearctic region; Neotropical region; North Africa; Oriental region.

G e n e r a o f H o s t – P l a n t s
Barbarea, Brassica, Cakile, Cleome, ***Diplotaxis****, Hirschfeldia, Isatis, Lepidium, Matthiola, Moricandia, Pisum, Raphanus, Reseda,* ***Silene****, Sinapis, Sisymbrium, Tropaeolum.*

M a t e r i e l e x a m i n e d
[68] Tinença de Benifassà: [1♂,2♀] s.20.ix.2006, e.02.x.2006, TB1. Host: ***Diplotaxis erucoides* L.** (*New interaction*)

[69] Tinença de Benifassà: [4♂,3♀] s.12.vi.2006, e.23.vi.2006, TB3. Font Roja: [1♂,1♀] s.11.v.2006, e.26.v.2006, FR3. Host: ***Hirschfeldia incana* (L.)**

[70] Font Roja: [14♂,11♀] s.24.v.2006, e.10.vi.2006; [1♂] s.28.viii.2006, e.07.ix.2006; [10♂,10♀] s.07.ix.2006, e.22.ix.2006, FR7. Host: ***Lepidium draba* L.**

[71] Font Roja: [1♂] s.26.vi.2007, e.27.vii.2007, FR3. Host: ***Reseda luteola* L.**

[72] Tinença de Benifassà: [1♂] s.20.ix.2006, e.02.x.2006, TB1. Host: ***Silene vulgaris* (Moench)** (*New interaction*)

[73] Font Roja: [1♂,3♀] s.20.iv.2006, 1♂ e.26.iv.2006 and 3♀ e.08.v.2006; [12♂,11♀] s.24.v.2006, e.21.vi.2006, FR7. Lagunas de La Mata-Torrevieja: [1♂] s.30.iv.2007, e.26.v.2007, TRV3. Host: ***Sysimbrium irio* L.**

[74] Font Roja: [2♂,12♀] s.07.vi.2007, e.21.vi.2007, FR3. Host: ***Sysimbrium officinale* (L.)**

[75] Font Roja: [1♂,2♀] s.07.vi.2007, e.23.vi.2007, FR4. [11♂,11♀] s.07.vi.2007, 2♂2♀ e.16.vi.2007, 3♂4♀ e.23.vi.2007, 4♂2♀ e.29.vi.2007, 2♂3♀ e.05.vii.2007, FR3. Host: ***Sysimbrium orientale* L.**

N o t e. *Liriomyza brassicae* was described in the United States on *Brassica* and is now known on 16 further genera. It is semi-cosmopolitan present throughout the Old World Tropics, particularly on Capparaceae and *Tropaeolum* (Tropaeolaceae), a favourite host, on which it occurs commonly in Australia, including Tasmania. It occurs occasionally on Resedaceae and an unusual switch is represented by its occasional occurrence on *Pisum*, on which it has been found on several occasions in Kenya and India. The male genitalia suggests possible relationship with *Liriomyza baccharidis* Spencer, 1963 (Compositae). Although *L. brassicae* cannot be reliably distinguished from the important pest *Liriomyza sativae* Blanchard, 1938 on external characters, the genitalia is enterily distinct.

Liriomyza bryoniae (Kaltenbach, 1858)

solani Hering, 1927
hydrocotylae Hering, 1930
mercurialis Hering, 1932
triton Frey, 1945
citrulli Rohdendorf, 1950
nipponallia Sasakawa,1961

D i s t r i b u t i o n
Palaearctic: Albania, Austria, Azores, Belarus, Belgium, Britain Islands, Bulgaria, Canary Islands, Channel Islands, Corsica, Crete, Croatia, Cyclades Islands, Czech republic, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Greek mainland, Hungary, Italian mainland, Lithuania, Malta, Republic of Moldova, Norwegian mainland, Poland, Portuguese mainland, Romania, Sicily, Slovenia, Spanish mainland, Sweden, The Netherlands, Ukraine, Yugoslavia; East Palaearctic; Near East; North Africa; Oriental region.

G e n e r a o f H o s t – P l a n t s
Aethionema, Alisma, Alliaria, Ajuga, Amaranthus, Anarrhinum, Anthyllis, Antirrhinum, Apium, Arabis, Astragalus, Atriplex, Atropa, Barbarea, Basella, Beta, Brugmansia, Bryonia, Caiophora, Callistephus, Capsella, Capsicum, Celosia, Centaurea, Centaurium, Centranthus, Chaenorhinum, Chenopodium, Chorispora, Cirsium,

Citrullus, Cleome, Collinsia, Coriandrum, Coronilla, Cucumis, Cucurbita, Cymbalaria, Dahlia, Datura, Diptychocarpus, Erysimum, Galega, Galeopsis, Galinsoga, Gerbera, Gentiana, Gypsophila, Heliophila, Hesperis, Hibiscus, Hydrocotyle, Hyoscyamus, Kickxia, Lactuca, Lagenaria, Lallemantia, Lamium, Lathyrus, Lavatera, Lens, Leonurus, Levisticum, Linaria, Lisianthus, Lupinus, Lycium, Lycopersicon, Malva, Maurandya, Medicago, Melilotus, Mercurialis, Nicandra, Nicotiana, Ononis, Oxalis, Oxytropis, Peltaria, Petroselinum, Petunia, Phacelia, Phaseolus, Phlox, Physalis, Piper, Pisum, Polemonium, Primula, Proboscidea, Raphanus, Ricinus, Salpiglossis, Saponaria, Scopolia, Scrophularia, Sedum, Sinapis, Sisymbrium, Solanum, Sonchus, Spergularia, Spinacia, Stellaria, Thermopsis, Trifolium, Trigonella, Tropaeolum, Verbascum, Verbena, Vicia, Withania.

M a t e r i e l e x a m i n e d
[76] Font Roja: [4♂,3♀] s.20.iv.2006, e.08.v.2006, FR7. Host: ***Sysimbrium irio*** **L.**

N o t e. *Liriomyza bryoniae* is a highly polyphagous species and occurs commonly as a significant pest on several genera of cultivated cucurbits in Europe but is rarely found on its original host, *Bryonia*. The larval has about ten spiracular pores on each process and the generally similar genitalia, *L. bryoniae* is closely related to *Liriomyza strigata (*Meigen, 1830), another polyphagous species which occurs most commonly on Compositae. However the leaf mines of the two species are entirely different, with *L. bryoniae* forming an irregular linear mine on any part of the leaf, while the mine of *L. strigata* always follows the midrib, with short offshoots into the leaf blade.

Liriomyza cicerina (Rondani, 1875)

ciceri (Navarro, 1903)
ononidis de Meijere, 1925
trichophthalma Hendel, 1931

D i s t r i b u t i o n
Austria, Britain Islands, Czech republic, Danish mainland, European Turkey, French mainland, Germany, Greek mainland, Italian mainland, Lithuania, Poland, Portuguese mainland, Romania, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Ukraine, Yugoslavia; Near East; North Africa.

G e n e r a o f H o s t – P l a n t s
Cicer, Hymenocarpos, ***Medicago****, Melilotus, Ononis.*

M a t e r i e l e x a m i n e d
[77] Font Roja: [1♂] s.04.x.2006, e.19.x.2006, FR3. Host: ***Medicago sativa*** **L.** (*New interaction*)

N o t e. *Liriomyza cicerina* feeds mainly on *Cicer arietinum* L. in the Mediterranean area, on which it can be a serious pest. The genitalia shows that it is related to species on Compositae, for example *Liriomyza sonchi* Hendel, 1931.

Liriomyza congesta (Becker, 1903)

leguminosarum de Meijere, 1924
minima Hendel, 1931
parva Hendel, 1931

centaureana Hering, 1936
nigripleura Rydén, 1956
taraia Garg, 1971
trifolii : authors (nec Burgess, 1880)

D i s t r i b u t i o n
Palaearctic: Albania, Austria, Belgium, Britain Islands, Canary Islands, Corsica, Czech republic, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Hungary, Ireland, Italian mainland, Latvia, Lithuania, Malta, Republic of Moldova, Norwegian mainland, Poland, Romania, Sardinia, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; East Palaearctic; Near East; North Africa; Oriental region.

G e n e r a o f H o s t – P l a n t s
Anthyllis, Astragalus, Caragana, Cicer, Colutea, Coronilla, Euphorpbia, Glycine, Glycirrhiza, Hippocrepis, Hymenocarpos, Lathyrus, Lens, Lotus, Lupinus, Medicago, Melilotus, Onobrychis, Ononis, Ornithopus, Oxytropis, Phaseolus, Pisum, Robinia, Scorpiurus, Trifolium, Trigonella, Vicia.

M a t e r i e l e x a m i n e d
[78] Font Roja: [1♂,1♀] s.14.vi.2006, e.29.vi.2006, FR2. Host: ***Astragalus sesameus* L.**

[79] Tinença de Benifassà: [1♀] s.05.vi.2006, e.23.vi.2006, TB3. Host: ***Lathyrus aphaca* L.**

[80] Tinença de Benifassà: [1♂,3♀] s.29.v.2006, e.16.vi.2006, TB5. Host: ***Lathyrus latifolius* L.**

[81] Font Roja: [27♂,40♀] s.29.vi.2006, 5♂9♀ e.10.vii.2006 and 22♂31♀ e.17.vii.2006, FR4. Host: ***Lotus corniculatus* L.**

[82] Tinença de Benifassà: [2♀] s.19.vi.2006, e.05.vii.2006, TB5. Host: ***Medicago lupulina* L.**

[83] Tinença de Benifassà: [1♂,1♀] s.22.v.2006, e.09.vi.2006, TB3. [1♂,1♀] s.05.vi.2006, e.23.vi.2006, TB6. Host: ***Medicago sativa* L.**

[84] Lagunas de La Mata-Torrevieja: [1♀] s.14.iii.2007, e.29.iii.2007, TRV2. Host: ***Ononis ornithopodioides* L.**

[85] Tinença de Benifassà: [2♀] s.02.vii.2007, e.30.vii.2007, TB2. Host: ***Ononis spinosa* L.** subsp. ***australis* (Sirj.)**

[86] Tinença de Benifassà: [2♂,4♀] s.29.v.2006, e.16.vi.2006, TB3. Host: ***Vicia hirsuta* (L.)**

[87] Tinença de Benifassà: [14♂,13♀] s.05.vi.2006, e.23.vi.2006, TB6. Host: ***Vicia hybrida* L.**

[88] Tinença de Benifassà: [2♂,3♀] s.05.vi.2006, e.23.vi.2006, TB3. [1♂,4♀] s.19.vi.2006, 1♂3♀ e.05.vi.2006 and 1♀ e.17.vii.2006, TB5. Lagunas de La Mata-Torrevieja: [1♂] s.21.iii.2007, e.05.iv.2007, TV3. Host: ***Vicia sativa* L.**

[89] Lagunas de La Mata-Torrevieja: [6♂,9♀] s.30.iv.2007, 5♂8♀ e.18.v.2007 and 1♂1♀ e.31.v.2007, TRV3. Host: ***Vicia villosa* Roth**

N o t e. *Liriomyza congesta* in Europe is common on *Lathyrus*, *Pisum*, *Vicia*, and has been recorded on *Lens*; it is also common on the Trifolieae. It is part of the oligophagous species of *Liriomyza* commonly attacking the family Leguminosae.

Liriomyza dianthicola (Venturi, 1949)

jannonei Séguy 1950

D i s t r i b u t i o n
Palaearctic: Belgium, Czech republic, French mainland, Hungary (doubtful), Italian mainland, Spanish mainland; East Palaearctic; Neotropical region.

G e n e r a o f H o s t – P l a n t s
Dianthus

M a t e r i e l e x a m i n e d
[90] Tinença de Benifassà: [1♂,1♀] s.23.vii.2007, e.01.viii.2007, TB3. Host: ***Dianthus broteri* Boiss Reuter**

N o t e. Two *Liriomyza* species are known in Europe on *Dianthus* and *Gypsophila*. *Liriomyza dianthicola* has only been found on cultivated *Dianthus*. It is an anomalous species, with the third antennal segment slightly angled and the costal ending shortly after the termination of the vein R_{4+5}. We found *L. dianthicola* undermining the stem of *Dianthus broteri* Boiss. & Reut.

Liriomyza orbona (Meigen, 1830)

fuscolimbata Strobl 1900
orbonella Hendel 1931

D i s t r i b u t i o n
Palaearctic: Britain Islands, Canary Islands, Channel Islands, Crete, Czech Republic, Danish mainland, Dodecanese Islands, European Turkey, Finland, French mainland, Germany, Hungary, Ireland, Italian mainland, Lithuania, Madeira, Malta, Poland, Sicily, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; Near East; North Africa.

G e n e r a o f H o s t – P l a n t s
Avena, Deschampsia, ***Hordeum****, Poa*

M a t e r i e l e x a m i n e d
[91] Font Roja: [1♀] s.21.ix.2006, e.12.x.2006, FR3. Host: ***Hordeum murinum* L.** (*New interaction*)

N o t e. *Liriomyza orbona* has been described on Avenae and Poeae, common in Spring. Male genitalia indicating close relationship with *Liriomyza phryne* Hendel, 1931.

Liriomyza pascuum (Meigen, 1838)

D i s t r i b u t i o n
Palaearctic: Belgium, Britain Islands, Corsica, Germany, French mainland, Poland, Romania, Spanish mainland.

G e n e r a o f H o s t – P l a n t s
Euphorbia

M a t e r i e l e x a m i n e d
[92] Tinença de Benifassà: [2♂,4♀] s.20.ix.2006, e.26.ix.2006, TB4. Host: ***Euphorbia characias* L.**

[93] Tinença de Benifassà: [2♂] s.18.vi.2007, e.01.vii.2007, TB2. Host: ***Euphorbia nicaeensis* All.**

N o t e. According to MARTINEZ & SOHBIAN (1998), six species of *Liriomyza* are reported as leaf miners on *Euphorbia* spp. Five are found only on *Euphorbia* spp.: *Liriomyza balcanica* (Strobl, 1898), *L. heringi* Nowakowski, 1961, *L. myrsinitae* Hering, 1957, *L. euphorbiae* Martinez, 1998, and *L. pascuum*. The sixth, *L. strigata* (Meigen, 1830) is polyphagous, reported from over 34 families and more than 240 genera of plants, but rarely found on *Euphorbia*.

Liriomyza strigata (Meigen, 1830)
galeopsios (Hardy, 1853)
pumila (Meigen, 1830)
violae (Curtis, 1844)

D i s t r i b u t i o n
Palaearctic: Albania, Belarus, Belgium, Britain Islands, Corsica, Cyclades Islands, Czech republic, Danish mainland, Dodecanese Islands, Estonia, European Turkey, Finland, French mainland, Germany, Greek mainland, Hungary, Ireland, Italian mainland, Lithuania, Madeira, North Aegean Islands, Norwegian mainland, Poland, Romania, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands; Oriental region.

G e n e r a o f H o s t – P l a n t s
Achillea, Ageratum, Ajuga, Alliaria, Allium, Althaea, Alyssum, Amaranthus, Ambrosia, Ammi, Anaphalis, Andryala, Anoda, Anthemis, Anthyllis, Antirrhinum, Apium, Aposeris, Arabidopsis, Arabis, Arctium, Arctotis, Artemisia, Aster, Astragalus, Atriplex, Barbarea, Bellis, Beta, Bidens, Brassica, Brillantaisia, Bryonia, Bunias, Buphthalmum, Calendula, Calepina, Callistephus, Campanula, Canarina, Cannabis, Capsella, Cardamine, Carduus, Carthamus, Cedronella, Centaurea, Centranthus, Cephalaria, Chrysanthemum, Cichorium, Cirsium, Cleome, Centaurea, Cochlearia, Coincya, Coleostephus, Collinsia, Conyza, Coreopsis, Coriandrum, Coringia, Crambe, Crepis, Cucumis, Cucurbita, Cynara, Dahlia, Dimorphotheca, Diplotaxis, Doronicum, Dracocephalum, Ecballium, Emilia, Erechtites, Erigeron, Eruca, Eryngium, Erysimum,

Euonymus, Eupatorium, Euphorbia, Filago, Fedia, Filago, Gaillardia, Galega, Galeopsis, Galinsoga, Gazania, Glaucium, Glechoma, Gnaphalium, Helenium, Helianthus, Helichrysum, Heliotropium, Heracleum, Hesperis, Hieracium, Hirschfeldia, Hydrocotyle, Hymenocarpos, Hyoscyamus, Hypochaeris, Iberis, Inula, Ipomoea, Isatis, Iva, Jasione, Jurinea, Kickxia, Kitaibela, Knautia, Lactuca, Lallemantia, Lamium, Lapsana, Lathyrus, Legousia, Leontodon, Leontopodium, Leonurus, Lepidium, Leucanthemum, Linaria, Linum, Loasa, Lobelia, Luffa, Lupinus, Lycopersicon, Malcolmia, Malva, Matricaria, Matthiola, Maurandya, Meconopsis, Medicago, Mentzelia, Mycelis, Nemesia, Nepeta, Nicotiana, Ocimum, Omphalodes, Ononis, Onopordum, Papaver, Peltaria, Perezia, Pericallis, Phacelia, Phaseolus, Phlox, Phyteuma, Picris, Pisum, Plantago, Polemonium, Prenanthes, Primula, Raphanus, Reichardia, Reseda, Ricinus, Rorippa, Rudbeckia, Salvia, Saponaria, Scabiosa, Scrophularia, Securinega, Senecio, Sidalcea, Silene, Sinapis, Sisymbrium, Solanum, Solidago, Sonchus, Spergularia, Spilanthes, Stachys, Stellaria, Succisa, Symphyandra, Tanacetum, Taraxacum, Telekia, Teucrium, Thlaspi, Tolpis, Tordylium, Trachelium, Tragopogon, Tridax, Trifolium, Trigonella, Tropaeolum, Tussilago, Vaccaria, Valeriana, Valerianella, Verbascum, Verbena, Veronica, Vicia, Vigna, Viola, Xanthium, Xeranthemum, Zinnia.

Materiel examined
[94] Tinença de Benifassà: [1♂,3♀] s.19.vi.2006, 3♀ e.10.vii.2006 and 1♂ e.17.vii.2006; [1♀] s.25.ix.2006, e.10.x.2006, TB3. Host: ***Diplotaxis erucoides* L.**

[95] Tinença de Benifassà: [1♀] s.15.v.2006, e.09.vi.2006, TB6. Host: ***Knautia rupicola* (Willk.)**

[96] Tinença de Benifassà: [1♀] s.08.v.2006, e.03.vi.2006, TB6. Host: ***Lepidium draba* L.**

[97] Tinença de Benifassà: [1♀] s.25.ix.2006, e.10.x.2006, TB1. Host: ***Lycopersicon esculentum* Mill.**

[98] Font Roja: [2♂,1♀] s.24.v.2007, e.09.vi.2007, FR3. Host: ***Sysimbrium orientale* L.**

Note. *Liriomyza strigata* has been recorded on 214 genera, and *Sonchus* is possibly the favourite host genus. The genitalia indicate close relationship with *L. bryoniae* and the North American *L. huidobrensis* (Blanchard, 1926) but the larval feeding with the mine closely associated with the midrib and lateral veins, suggests unmistakably a sister-group relationship with *L. huidobrensis*.

Liriomyza trifolii (Burgess *in* Comstock, 1880)

phaseolunulata Frost, 1943
alliovora Frick, 1955

Distribution
Palaearctic: Austria, Belgium, Britain Islands, Bulgaria, Canary Islands, Corsica, Crete, Cyprus, Czech republic, European Turkey, Finland, French mainland, Germany, Greek mainland, Hungary, Ireland, Italian mainland, Malta, Monaco, Norwegian mainland, Poland, Portuguese mainland, Romania, Sardinia, Sicily, Slovakia, Slovenia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; Afro-Tropical region;

Australian region; East Palaearctic; Near East; Nearctic region; Neotropical region; North Africa; Oriental region.

G e n e r a o f H o s t – P l a n t s
Abelmoschus, Ageratum, Agrimonia, Ajuga, Allium, Alstroemeria, Amaranthus, Ambrosia, Anemone, Anethum, Anthriscus, Antirrhinum, Apium, Arachis, Arctium, Artemisia, Asclepias, Aster, Avena, Baccharis, Basella, Bellis, Beta, Bidens, Brachycome, Brassica, Bryonia, Cajanus, Callistephus, Callistephus, Canavalia, Capraria, Capsella, Capsicum, Cardiospermum, Carthamus, Cassia, Celosia, Centaurea, Centranthus, Cestrum, Chelone, Chenopodium, Chrysanthemum, Cirsium, Citrullus, Conoclinium, Convolvulus, Conyza, Crataegus, Crotalaria, Cucumis, Cucurbita, Dahlia, Datura, Daucus, Dendranthema, Dianthus, Dimorphotheca, Erechtites, Erigeron, Eupatorium, Fallopia, Flaveria, Fuchsia, Gaillardia, Galinsoga, Gazania, Gerbera, Gladiolus, Glycine, Gnaphalium, Gossypium, Gypsophila, Helianthus, Helichrysum, Hibiscus, Holmskioldia, Hordeum, Hydrocotyle, Hymenopappus, Ipomoea, Kallstroemia, Lactuca, Lamium, Lannea, Lantana, Lathyrus, Launaea, Leucanthemum, Linaria, Lycopersicon, Medicago, Melilotus, Moluccella, Momordica, Nepeta, Ocimum, Passiflora, Pastinaca, Peperomia, Peristrophe, Petroselinum, Petunia, Phaseolus, Phlox, Piper, Pisum, Plantago, Polygonum, Portulaca, Primula, Pupalia, Ranunculus, Raphanus, Ricinus, Rumex, Ruspolia, Salvia, Scaevola, Senecio, Solanum, Solidago, Sonchus, Spilanthes, Spinacia, Stellaria, Synedrella, Tagetes, Tanacetum, Taraxacum, Thlaspi, Tithonia, Trachelium, Tragopogon, Tribulus, Tridax, ***Urospermum****, Vernonia, Vicia, Vigna, Withania, Xanthium, Zinnia.*

M a t e r i e l e x a m i n e d

[99] Lagunas de La Mata-Torrevieja: [1♀] s.30.iv.2007, e.15.v.2007, TRV2. Host: ***Avena barbata* Pott ex Link**

[100] Lagunas de La Mata-Torrevieja: [2♀] s.14.iii.2007, e.29.iii.2007, TRV5. Host: ***Chrysanthemum coroniarum* L.**

[101] Lagunas de La Mata-Torrevieja: [1♂,2♀] s.16.v.2007, e.02.vi.2007, TRV5. Host: ***Sonchus tenerrimus* L.**

[102] Lagunas de La Mata-Torrevieja: [2♂,2♀] s.16.v.2007, e.02.vi.2007, TRV5. Host: ***Urospermum picroides* (L.)** (*New interaction*)

N o t e. *Liriomyza trifolii* was described from Washington, D.C. and is now known as one of the most polyphagous species in the Agromyzidae, with records on 33 families (BENAVENT-CORAI *et al.*, 2005). It has also developed a greater degree of resistance to insecticides than any other species and has been introduced widely to many countries, primarily with infested *Chrysanthemum* cuttings. This capacity is associated to its ability to adjust to the many chemical present in its wide range of hosts.

Genus ***Napomyza*** **Westwood, 1840**

Napomyza lateralis (Fallén, 1823)

D i s t r i b u t i o n
Palaearctic: Austria, Azores, Belarus, Belgium, Britain Islands, Canary Islands, Czech Republic, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Greek mainland, Hungary, Ireland, Italian mainland, Latvia, Lithuania, Madeira, Poland, Sicily, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; East Palaearctic (doubtful); Near East; Neartic region; North Africa.

G e n e r a o f H o s t – P l a n t s
Anthemis, Bellis, Bidens, Calendula, Carduus, Centaurea, Cirsium, Crepis, Helichrysum, Hypochaeris, Inula, Lactuca, Linum, Lupinus, Matricaria, Senecio, ***Urospermum****.*

M a t e r i e l e x a m i n e d
[103] Font Roja: [1♂,1♀] s.07.ix.2006, 1♀ e.15.ix.2006 and 1♂ e.02.x.2006, FR7. Host: ***Urospermum picroides*** **(L.)** (*New interaction*)

[104] Font Roja: [1♂] s.18.v.2006, e.10.vi.2006, FR3. Host: ***Crepis albida*** **Vill.**

N o t e. *Napomyza lateralis* is considered a species highly oligophagous or pre-polyphagous. Its high similarity to other species present on Compositae, as well as in other close families can indicate they were a group of different species. It should confirm if this is really the only specimen described as *Napomyza lateralis* in Sweden.

Genus ***Phytomyza*** **Fallén, 1810**

Phytomyza hellebori Kaltenbach, 1872
hellebori buhri Hering, 1930
helleborina Hering, 1932

D i s t r i b u t i o n
Palaearctic: Britain Islands, Corsica, Finland, French mainland, Germany, Italian mainland.

G e n e r a o f H o s t – P l a n t s
Helleborus

M a t e r i e l e x a m i n e d
[105] Tinença de Benifassà: [1♀] s.20.ix.2006, e.12.x.2006, TB2. [2♀] s.20.ix.2006, e.12.x.2006, TB5. Host: ***Helleborus foetidus*** **L.**

N o t e. *Phytomyza hellebori* forms linear-blotch mines on many species of this genus. The genitalia indicate relationship with species on both, *Anemone* (*P. anemones* Hering, 1925) and *Ranunculus* (*P. fallaciosa* Brischke,1880).

Phytomyza plantaginis Robineau-Desvoidy, 1851

plantaginis Goureau, 1851
robinaldi Goureau, 1851
genualis Loew, 1869
nannodes Hendel, 1935
biseriata Hering, 1937
plantaginicaulis Hering, 1944

D i s t r i b u t i o n
Palaearctic: Azores, Belarus, Britain Islands, Canary Islands, Channel Islands, Czech republic, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Hungary, Ireland, Italian mainland, Latvia, Lithuania, Republic of Moldava, Norwegian mainland, Poland, Romania, Slovakia, Spanish mainland, Sweden, Switzerland, The Netherlands, Yugoslavia; Australian region; East Palaearctic; Near East; Nearctic region; Neotropical region; Oriental region.

G e n e r a o f H o s t – P l a n t s
Plantago

M a t e r i e l e x a m i n e d

[106] Lagunas de La Mata-Torrevieja: [1♂,2♀] s.18.iv.2007, e.25.iv.2007, TRV2. Host: ***Plantago albicans*** **L.**

[107] Tinença de Benifassà: [1♂] s.19.vi.2006, e.17.vii.2006; [1♂,1♀] s.11.vi.2007, e.21.vi.2007, TB2. Lagunas de La Mata-Torrevieja: [1♂,1♀] s.07.iii.2007, e.22.iii.2007; [7♂,8♀] s.04.iv.2007, e.19.iv.2007; [40♂,31♀] s.18.iv.2007, e.04.v.2007; [2♂,2♀] s.16.v.2007, e.31.v.2007, TRV3. Host: ***Plantago lagopus*** **L.**

[108] Font Roja: [1♀] s.18.v.2006, e.10.vi.2006; [1♂] s.07.vi.2006, e.16.vi.2006, FR4. [4♂] s.07.vi.2006, e.23.vi.2006, FR6; [2♂] s.22.vi.2006, 1♂ e.10.vii.2006 and 1♂ 17.vii.2006, FR3. Host: ***Plantago lanceolata*** **L.**

N o t e. *Phytomyza plantaginis* has been described on *Plantago*, exclusively. Males are known in Europe but the species appears to be parthenogenetic in the areas where it has been introduced. The larva pupates in the leaf. Feeding may also take place in the stem and such specimens were described as *P. plantaginicaulis* Hering (1944) (synonymy with *plantaginis* established by SPENCER, 1963).

Pseudonapomyza atratula Zlobin, 2002

D i s t r i b u t i o n
Palaearctic: Tunisia

G e n e r a o f H o s t – P l a n t s
Avena

M a t e r i e l e x a m i n e d
[109] Lagunas de La Mata-Torrevieja: [2♀] s.30.iv.2007, 1♀ e.18.v.2007 and 1♀ e.31.v.2007, TRV2. Host: ***Avena barbata*** **Pott ex Link** (*New interaction*)

[110] Lagunas de La Mata-Torrevieja: [1♂] s.30.iv.2007, e.26.v.2007, TRV1. Host: ***Avena fatua* L.** (*New interaction*)

N o t e. *Pseudonapomyza atratula* Zlobin, 2002 was found for the first time in Tunisia (1976). On external characters and especially in the structure of male genitalia *P. atratula* is most closely related to the *P. atra* (Meigen, 1830). Both species can be separated by some peculiarities in the shape of aedeagus and spermathecae (ZLOBIN, 2002a). Actually it has been found in the locality of Torrevieja, thus constituting the first appointment of *P. atratula* in Europe. It was cited for the first time on genus *Avena* (Fam. Graminae), as one of the host-genera mined by *P. atratula*.

Below (Table 6-2) it is presented the summary list of 110 plant-Agromyzidae interactions including 31 new interactions for the science belonging to Agromyzidae species known. It is cited the presence of two endemic interactions in "Font Roja" (Alcoy): *Chromatomyia horticola* (Goureau, 1851) on *Centaurea mariolensis* Rouy and *Centaurea rouyi* Coincy.

AGROMYZINAE SPECIES	LOCALITY	PLANT SPECIES
Ophiomyia beckeri (Hendel, 1923)	FR	*Centaurea rouyi* Coincy (*)
	TB	*Crepis bursifolia* L.
	FR	*Crepis vesicaria* L.
	FR	*Lepidium draba* L. (*)
	TB,TRV	*Reichardia picroides* (L.) (*)
	FR,TRV	*Sonchus oleraceus* L.
	TB,TRV	*Sonchus tenerrimus* L.
	FR	*Sysimbrium irio* L. (*)
	FR	*Taraxacum obovatum* (Willd.)
	TRV	*Urospermum picroides* (L.) (*)
Ophiomyia ononidis Spencer, 1966	TB	*Lotus corniculatus* L. (*)
	TB,FR	*Medicago sativa* L.

PHYTOMYZINAE SPECIES	LOCALITY	PLANT SPECIES
Amauromyza (Amauromyza) balcanica (Hendel, 1931)	TB	*Phlomis lychnitis* L.
Amauromyza (Amauromyza) carlinae (Hering, 1944)	FR	*Cirsium vulgare* (Savi)
Amauromyza (Amauromyza) morionella (Zetterstedt, 1848)	FR	*Marrubium vulgare* L.
Amauromyza (Cephalomyza) flavifrons (Meigen, 1830)	FR	*Catananche caerulea* L. (*)
	FR	*Lepidium draba* L. (*)
	FR	*Silene conica* L.
	FR	*Silene conoidea* L.
Amauromyza (Cephalomyza) karli (Hendel, 1927)	TB	*Chenopodium vulvaria* L. (*)
Chromatomyia horticola (Goureau, 1851)	FR	*Anagallis arvensis* L. (*)
	TRV	*Avena byzanthina* C. Koch (*)
	FR	*Blackstonia perfoliata* (L.) (*)
	TB	*Carduncellus monspeliensum* All.
	TB,FR,TRV	*Carduus pycnocephalus* L.
	FR	*Catananche caerulea* L. (*)
	FR,TRV	*Centaurea aspera* L.

	FR	*Centaurea mariolensis* Rouy
	TB	*Centaurea scabiosa* L.
	TB,TRV	*Centaurea seridis* L.
	TB	*Centaurea triumfetti* All.
	TRV	*Chrysanthemum coroniarum* L.
	TRV	*Convolvulus althaeoides* L.
	FR,TRV	*Crepis vesicaria* L.
	FR	*Cynoglossum cheirifolium* L.
	TB,FR,TRV	*Diplotaxis erucoides* (L.) DC.
	TB,TRV	*Echium vulgare* L.
	FR	*Hirschfeldia incana* (L.)
	TB	*Knautia arvensis* (L.)
	TB	*Knautia purpurea* (Vill.)
	FR	*Lepidium draba* L.
	FR	*Leucanthemum gracilicaule* (Dufour)
	FR	*Lithospermum arvense* L.
	FR	*Malva parviflora* L.
	FR	*Mantisalca salmantica* (L.) (*)
	TB	*Medicago sativa* L.
	TB,FR,TRV	*Papaver rhoeas* L.
	TRV	*Phagnalon saxalite* (L.) (*)
	TB,TRV	*Plantago lagopus* L.
	TB	*Plantago lanceolada* L.
	FR	*Reseda stricta* pers.
	TB	*Scabiosa atropurpurea* L. (*)
	FR	*Serratula pinnatifida* (Cav.) (*)
	FR	*Silene conoidea* L.
	FR	*Sinapis alba* L.
	TB,FR,TRV	*Sonchus oleraceus* L.
	TB,TRV	*Sonchus tenerrimus* L.
	FR	*Sysimbrium crassifolium* Cav.
	FR,TRV	*Sysimbrium irio* L.
	FR	*Sysimbrium officinale* (L.)
	FR	*Sysimbrium orientale* L.
	FR	*Taraxacum obovatum* (Willd.)
	TB	*Taraxacum vulgare* (Lam.)
	TRV	*Urospermum picroides* (L.) (*)
	TB	*Vicia sativa* L.
	FR	*Xeranthemum inapertum* (L.) (*)
Chromatomyia periclymeni (Hendel, 1922)	FR	*Lonicera etrusca* G. Santi
Liriomyza brassicae (Riley, 1884)	TB	*Diplotaxis erucoides* L. (*)
	TB,FR	*Hirschfeldia hincana* (L.)
	FR	*Lepidium draba* L.
	FR	*Reseda luteola* L.
	TB	*Silene vulgaris* (Moench) (*)
	FR,TRV	*Sysimbrium irio* L.
	FR	*Sysimbrium officinale* (L.)
	FR	*Sysimbrium orientale* L.
Liriomyza bryoniae (Kaltenbach, 1858)	FR	*Sysimbrium irio* L.
Liriomyza cicerina (Rondani, 1875)	FR	*Medicago sativa* L. (*)
Liriomyza congesta (Becker, 1903)	FR	*Astragalus sesameus* L.
	TB	*Lathyrus aphaca* L.
	TB	*Lathyrus latifolius* L.
	FR	*Lotus corniculatus* L.
	TB,FR	*Medicago lupulina* L.
	TB,FR	*Medicago sativa* L.
	TRV	*Ononis ornithopodioides* L.
	TB	*Ononis spinosa* L. subsp. *australis* (Sirj.)
		Vicia hirsuta (L.)
	TB	*Vicia hybrida* L.
	TB	*Vicia sativa* L.
	TB,TRV	*Vicia villosa* Roth

	TRV	
Liriomyza dianthicola (Venturi, 1949)	TB	*Dianthus broteri* Boiss Reuter
Liriomyza orbona (Meigen, 1830)	FR	*Hordeum murinum* L.
Liriomyza pascuum (Meigen, 1838)	TB	*Euphorbia characias* L.
	TB	*Euphorbia nicaeensis* All.
Liriomyza strigata (Meigen, 1830)	TB	*Diplotaxis erucoides* L.
	TB	*Knautia rupicola* (Willk.)
	TB,FR	*Lepidium draba* L.
	TB	*Lycopersicon esculentum* Mill.
	FR	*Sysimbrium orientale* L.
Liriomyza trifolii (Burgess *in* Comstock, 1880)	TRV	*Avena barbata* Pott ex Link
	TRV	*Chrysanthemum coroniarum* L.
	TRV	*Sonchus tenerrimus* L.
	TRV	*Urospermum picroides* (L.) (*)
Napomyza lateralis (Fallén, 1823)	FR	*Urospermum picroides* (L.) (*)
	FR	*Crepis albida* Vill.
Phytomyza hellebori Kaltenbach, 1872	TB	*Helleborus foetidus* L.
Phytomyza plantaginis Robineau-Desvoidy, 1851	TRV	*Plantago albicans* L.
	TB,FR,TRV	*Plantago lagopus* L.
	FR	*Plantago lanceolata* L.
Pseudonapomyza atratula Zlobin, 2002	TRV	*Avena barbata* Pott ex Link (*)
	TRV	*Avena fatua* L. (*)

(*) New interactions

Table 6-2. Table summary of interactions plant-Agromyzidae belonging to the Natural Parks of “Tinença de Benifassà”,”Font Roja” and “Lagunas de La Mata-Torrevieja”.

Other interactions plant-genera of unspecific Agromyzidae are presented in Table 6-3. The doubtful identification of some specimens due to the only obtaining of females, obliges to indicate the miners only at level of genera.

Liriomyza sp.

M a t e r i e l e x a m i n e d
[111] Lagunas de La Mata-Torrevieja: [1♀] s.30.iv.2007, e.18.v.2007, TRV3. Host: ***Bellardia trixago* (L.)** (*New interaction*)

Liriomyza sp.

M a t e r i e l e x a m i n e d
[112] Lagunas de La Mata-Torrevieja: [1♀] s.28.ii.2007, e.22.iii.2007, TRV2. Host: ***Carrichtera annua* (L.)** (*New interaction*)

Liriomyza sp.

M a t e r i e l e x a m i n e d
[113] Font Roja: [1♀] s.07.vi.2007, e.21.vi.2007, FR3. Host: ***Rapistrum rugosum* (L.)** (*New interaction*)

Phytomyza sp.

M a t e r i e l e x a m i n e d
[114] Lagunas de La Mata-Torrevieja: [1♀] s.21.iii.2007, e.05.iv.2007, TRV9. Host: ***Serratula flavescens* (L.)** (*New interaction*)

Pseudonapomyza sp.

M a t e r i e l e x a m i n e d
[115] Lagunas de La Mata-Torrevieja: [1♀] s.19.iv.2006, e.02.v.2006, TRV9. Host: ***Piptatherum miliaceum* (L.)** (*New interaction*)

PHYTOMYZINAE SPECIES	**LOCALITY**	**PLANT SPECIES**
Liriomyza sp.	TRV	Bellardia trixago (L.) (*)
Liriomyza sp.	TRV	Carrichtera annua (L.) (*)
Liriomyza sp.	FR	Rapistrum rugosum (L.) (*)
Phytomyza sp.	TRV	Serratula flavescens (L.) (*)
Pseudonapomyza sp.	TRV	Piptatherum miliaceum (L.) (*)

(*) New interactions

Table 6-3. Table summary of unspecific plant-genera interactions of Agromyzidae belonging to the Natural Parks “Font Roja” and “Lagunas de La Mata-Torrevieja”.

Table 6-4 shows the entire mined host-plants list from the three parks studied. It was highlighted in bold the plant species listed in Table 6-3, while the rest refer to plants in which it is known they are mined by Agromyzidae but which has not been able to obtain the agromyzid.

PLANT FAMILY	**LOCALITY**	**PLANT SPECIES**
Boraginaceae	TB	*Cynoglossum creticum* Mill.
	TB,**FR**,TRV	***Cynoglossum cheirifolium* L.**
	TB,**TRV**	***Echium vulgare* L.**
	FR	*Heliotropium europaeum* L.
	FR,TRV	***Lithospermum arvense* L.**
	TRV	*Nonea vesicaria* (L.)
Caprifoliaceae	TB,**FR**	***Lonicera etrusca* G. Santi**
	TB,FR	*Lonicera implexa* Aiton
Caryophyllaceae	TB	*Dianthus broteri* Boiss Reuter
	FR	*Saponaria ocymoides* L.
	FR	***Silene conica* L.**
	FR	***Silene conoidea* L.**
	FR	*Silene dioica* (L.)
	FR	*Silene saxifraga* L.
	TB,FR,TRV	***Silene vulgaris* (Moench)**
Chenopodiaceae	**TB**	***Chenopodium vulvaria* L.**
	TRV	*Arthrocnemum macrostachyum* (Moric.) (*)
Compositae	TRV	*Asteriscus maritimus* (L.)
	TRV	*Calendula arvensis* L.

	TB,FR	***Carduncellus monspeliensium* All.**
	TB,**FR**,**TRV**	***Carduus pycnocephalus* L.**
	TB,TRV	*Carthamus lanatus* L.
	FR	***Catananche caerulea* L.**
	TB,**FR**,**TRV**	***Centaurea aspera* L. subsp. *stenophylla* (Dufour)**
	FR	***Centaurea mariolensis* Rouy**
	TRV	*Centaurea melitensis* L.
	FR,TRV	***Centaurea rouyi* Coincy**
	TB,FR	***Centaurea scabiosa* L.** subsp. ***cephalariifolia* (Willk.)**
	TB,**TRV**	***Centaurea seridis* L.**
	FR	*Centaurea solstitialis* L.
	FR	*Centaurea spachii* Schultz Bip. Ex Willk.
	TB	***Centaurea triumfettii* All subsp. *semidecurrens* (Jord.)**
	TB,**TRV**	***Chrysantemum coronarium* L.**
	FR	*Cirsium arvense* (L.)
	FR	***Cirsium vulgare* (Savi)**
	FR	***Crepis albida* Vill.**
	TB	***Crepis bursifolia* L.**
	TB,**FR**,**TRV**	***Crepis vesicaria* L.**
	TRV	*Dittrichia viscosa* (L.)
	TRV	*Inula crithmoides* L.
	FR	*Leontodon taraxacoides* (Vill.)
	FR	***Leucanthemum gracilicaule* (Dufour)**
	TB	*Leuzea conifera* (L.) (*)
	FR,TRV	***Mantisalca salmantica* (L.)**
	FR	*Matricaria chamomilla* L.
	TRV	***Phagnalon saxalite* (L.)**
	TRV	*Reichardia intermedia* (Schulz Bip.)
	TB,**TRV**	***Reichardia picroides* (L.)**
	TRV	*Reichardia tingitana* (L.)
	FR	*Scorzonera laciniata* L.
	TRV	*Senecio auricula* Bourg. Ex. Coss.
	FR,TRV	*Senecio vulgaris* L.
	TRV	***Serratula flavescens* (L.) subsp. *leucantha* (Cav.)**
	FR	***Serratula pinnatifida* (Cav.)**
	TB,**FR**,**TRV**	***Sonchus oleraceous* L.**
	TB,**FR**,**TRV**	***Sonchus tenerrimus* L.**
	TB,**FR**	***Taraxacum obovatum* (Willd.)**
	TB	***Taraxacum vulgare* (Lam.)**
	TB	*Urospermum delechampii* (L.)
	TB,**FR**,**TRV**	***Urospermum picroides* (L.)**
	TB,**FR**	***Xeranthemum inapertum* (L.)**
Convolvulaceae	FR,**TRV**	***Convolvulus althaeoides* L.**
Cruciferae	**TRV**	***Carrichtera annua* (L.)**
	TB,**FR**,**TRV**	***Diplotaxis erucoides* (L.)**
	TRV	*Eruca vesicaria* (L.)
	TB,**FR**	***Hirschfeldia incana* (L.)**
	FR	*Iberis saxatilis* L.
	TB,**FR**	***Lepidium draba* L.**
	FR	***Rapistrum rugosum* (L.)**
	FR	***Sinapis alba* L.**
	FR	***Sisymbrium crassifolium* subsp. *laxiflorum* (Boiss.)**
	FR,**TRV**	***Sisymbrium irio* L.**
	FR,**TRV**	***Sisymbrium officinale* (L.)**
	FR	***Sisymbrium orientale* L.**
Dipsacaceae	**TB**	***Knautia arvensis* (L.)**
	TB	***Knautia purpurea* (Vill.)**
	TB	***Knautia rupicola* (Willk.)**
	TB,FR,TRV	***Scabiosa atropurpurea* L.**
Euphorbiaceae	**TB**	***Euphorbia characias* L.**
	TRV	*Euphorbia esula* L.
	TB,TRV	***Euphorbia nicaeensis* All.**
	TRV	*Euphorbia paralias* L.

	TB,TRV	*Euphorbia serrata* L.
Gentianaceae	**FR**	***Blackstonia perfoliata* (L.)**
Geraniaceae	FR	*Geranium rotundifolium* L.
	TRV	*Geranium molle* L.
Graminae	FR	*Arrhenatherum elatius* (L.)
	FR, **TRV**	***Avena barbata* Pott ex Link**
	TRV	***Avena byzanthina* C. Koch**
	TB,**TRV**	***Avena fatua* L.**
	FR,TRV	*Avena sativa* L.
	FR	*Avena sterilis* L.
	TB,FR	*Brachypodium retusum* (Pers.)
	TRV	*Bromus fasciculatus* Presl
	TB,FR	*Dactylis glomerata* L.
	FR,TRV	***Hordeum murimum* L. subsp. *leporinum* (Link)**
	TRV	***Piptatherum miliaceum* (L.)**
	TRV	*Setaria viridis* (L.)
Labiatae	TRV	*Ballota hirsuta* Benth.
	FR	***Marrubium vulgare* L.**
	TB,FR	***Phlomis lychnitis* L.**
	FR	*Teucrium ronnigeri* Sennen
Leguminosae	FR	*Anthyllis vulneraria* L.
	FR	***Astragalus sesameus* L.**
	FR	*Colutea arborescens* L.
	TB,FR,TRV	*Coronilla scorpioides* (L.)
	TB,FR	*Cytisus heterochrous* Webb ex Colmeiro
	TB,FR	*Cytisus reverchonii* (Degen & Hervier)
	TRV	*Hippocrepis comosa* L.
	TB	***Lathyrus aphaca* L.**
	TB	***Lathyrus latifolius* L.**
	TB	*Lathyrus saxatilis* (Vent.)
	TB,FR	***Lotus corniculatus* L.**
	TB,**FR**	***Medicago lupulina* L.**
	TB,FR,TRV	*Medicago minima* L.
	TB	*Medicago orbicularis* (L.)
	TRV	*Medicago polimorpha* L.
	FR	*Medicago rigidula* (L.)
	TB,**FR**,TRV	***Medicago sativa* L.**
	FR	*Medicago suffruticosa* Ramond ex DC.
	FR	*Melilotus officinalis* (L.)
	FR	*Ononis fruticosa* L. subsp. *macrophylla* (DC.)
	TRV	***Ononis ornithopodioides* L.**
	TB	***Ononis spinosa* L. subsp. *australis* (Sirj.)**
	TB	*Trifolium pratense* L.
	TB	*Trifolium repens* L.
	FR	*Trifolium scabrum* L.
	TB	***Vicia hirsuta* (L.)**
	TB,FR	***Vicia hybrida* L.**
	TB,FR,**TRV**	***Vicia sativa* L.**
	TRV	***Vicia villosa* Roth subsp. *varia* (Host)**
Malvaceae	**FR**	***Malva parviflora* L.**
Orchidaceae	TRV	*Ophrys speculum* Link (*)
Papaveraceae	**TB**,**FR**,**TRV**	***Papaver rhoeas* L.**
Plantaginaceae	**TRV**	***Plantago albicans* L.**
	TB,**FR**,**TRV**	***Plantago lagopus* L.**
	TB,**FR**	***Plantago lanceolata* L.**
Primulaceae	**FR**,TRV	***Anagallis arvensis* L.**

Ranunculaceae	TB	*Clematis vitalba* L.
	TB	***Helleborus foetidus* L.**
	TB	*Ranunculus sardous* Crantz.
	TB	*Thalictrum tuberosum* L.
Resedaceae	FR	*Reseda phyteuma* L.
	FR	***Reseda luteola* L.**
	FR	***Reseda stricta* Pers.**
Rosaceae	TB	*Prunus dulcis* (Mill.)
Rubiaceae	TRV	*Galium verrucosum* Huds.
Scrophulariaceae	**TRV**	***Bellardia trixago* (L.)**
Solanaceae	TB	*Hyoscyamus albus* L.
	TB	***Lycopersicon esculentum* Mill.**
Umbelliferae	TB,FR	*Bupleurum fruticescens* L.
	TB,FR	*Bupleurum rididum* L.
Urticaceae	TB	*Parietaria judaica* L.

(*) New host-plants for Agromyzidae. They appear highlighted in bold the species listed in Table 6-3.

Table 6-4. Table summary of host-plant Agromyzidae from “Tinença de Benifassà”, “Font Roja” and “Lagunas de La Mata-Torrevieja”.

Table 6-5 shows quantitatively the number of families and botanical genera listed in Table 6-4. All three Natural Parks have globally a similar number of families mined by Agromyzidae, but “Font Roja” has been the park with the most number of botanical genera affected.

	Tinença	**Font Roja**	**Torrevieja**	**Globally**
Families	17	18	17	27
Genera	45	60	49	94

Table 6-5. Quantitative table summary of genera and families listed in Table 6-4.

The families affected by Agromyzidae in “Tinença de Benifassà” were seventeen including Boraginaceae, Caprifoliaceae, Chenopodiaceae, Compositae, Cruciferae, Dipsacaceae, Euphorbiaceae, Graminae, Labiatae, Leguminosae, Papaveraceae, Plantaginaceae, Ranunculaceae, Rosaceae, Solanaceae, Umbeliferae, and Urticaceae (Fig. 6-2). The botanical families Compositae and Leguminosae have showed the largest number of botanical genera infested, with 26.9% and 23.9% respectively. Subsequently, the remaining families have been similar percentages below to 10%. It is observed a greater preference of Agromyzidae species by broad-leaved plants that leaf close.

“Font Roja” distribution of mined families was composed by Boraginaceae, Caprifoliaceae, Caryophyllaceae, Compositae, Convolvulaceae, Cruciferae, Dipsacaceae, Gentaniaceae, Graminae, Labiatae, Leguminosae, Malvaceae, Papaveraceae, Plantaginaceae, Primulaceae, Resedaceae, and Umbelliferae (Fig. 6-3). It emphasizes the presence of Compositae family (28,7%), followed by Leguminosae (19,5%), and Cruciferae (11,5%). Remaining families represent a percentage less than 10%, headed by Graminae (8%).

Figure 6-4 shows the number of botanical families infested in “Lagunas de La Mata-Torrevieja”. They are cited the presence of seventeen families composed by Boraginaceae, Caryophyllaceae, Chenopodiaceae, Compositae, Convolvulaceae, Cruciferae, Dipsacaceae, Euphorbiaceae, Geraniaceae, Graminae, Labiatae, Leguminosae, Orchidaceae, Papaveraceae, Plantaginaceae, Primulaceae, Rubiaceae, and Scrophulariaceae. Almost half of genera mined by Agromyzidae belong to the family Compositae (34,8%), followed by Graminae and Leguminosae (both 12,1%). All other families present rates below 10%, headed by Cruciferae (7,6%).

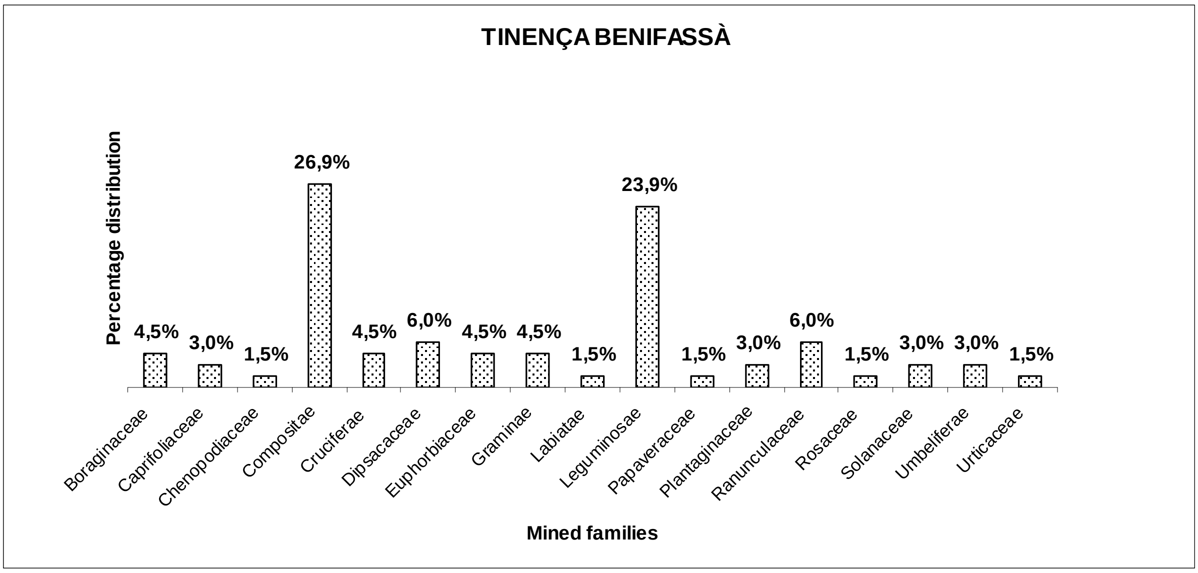

Figure 6-2. Percentage distribution of botanical families mined in “Tinença de Benifassà”.

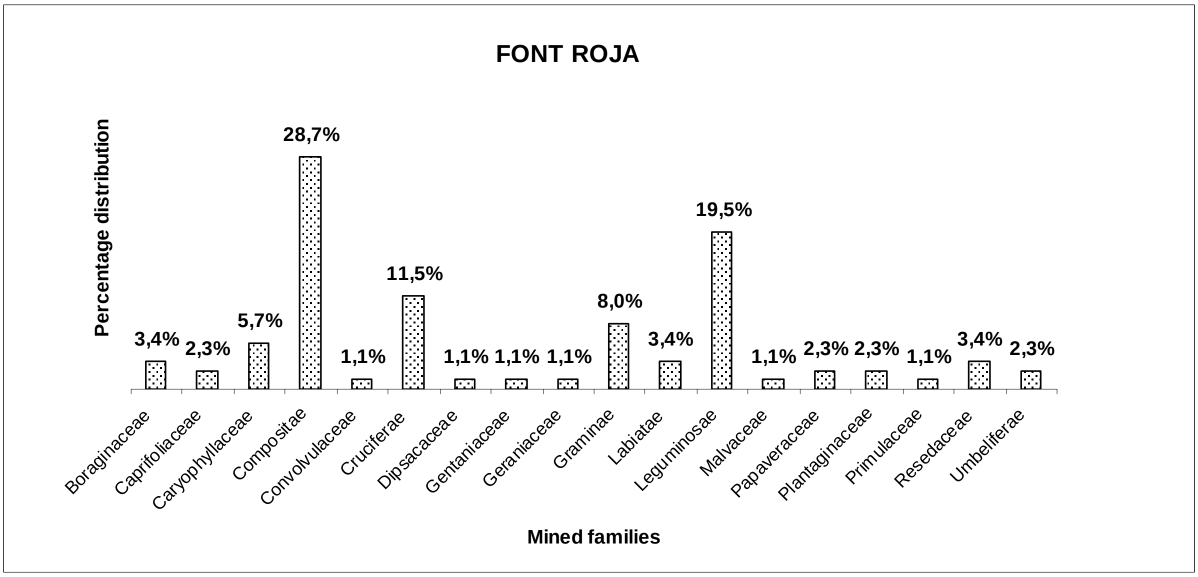

Figure 6-3. Percentage distribution of botanical families mined in “Font Roja”.

Globally the families with the most degree of infestation have been Compositae, and Leguminosae. Cruciferae and Graminae have presented a markedly lower rate of infestation than Compositae and Leguminosae, but higher levels in comparison with the remaining families. Agromyzidae preferences are close related to physical aspects and phytochemical composition of plants.

Host-plants listed in Table 4 have been breaking down in percentage, indicating the degree of families and genera participation by Agromyzidae. The largest botanical diversity observed in the "Tinença de Benifassà" and "Font Roja" is due to a lower rate of anthropical impact in these parks, constituting important flora microreserves from the community of Valencia.

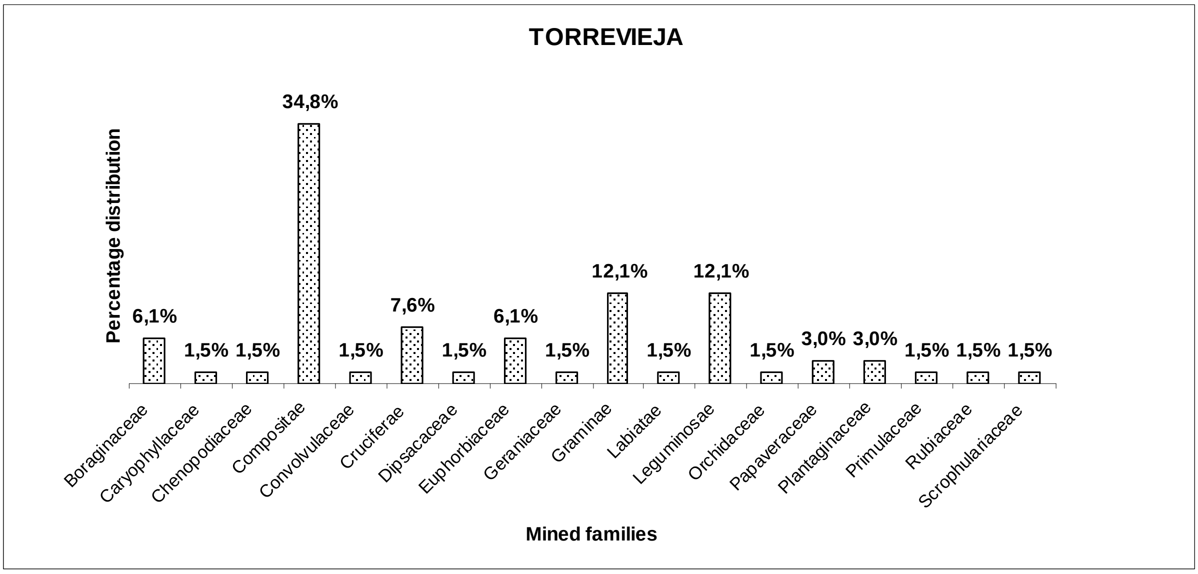

Figure 6-4. Percentage distribution of botanical families mined in "Lagunas de La Mata-Torrevieja".

Figures 6-4, 6-5 and 6-6 compare the percentage of genera distribution in the most mined botanical families: Compositae, Leguminosae, Cruciferae, and Graminae. The percentages indicate the relative importance in terms of the number of mined plant species included in each gender.

The largest number of plant species mined in the family Compositae belongs to the *Centaurea* genus with relative percentages estimated around to 20% from the three Natural Parks studied. In "Tinença de Benifassà" highlights *Crepis*, *Sonchus*, *Taraxacum* and *Urospermum* (all 11%). In "Font Roja", *Cirsium*, *Crepis* and *Sonchus* (all 8%). While in Torrevieja, *Senecio* and *Sonchus* (both 9%). The rest of botanical genera are composed by a similar number of species with percentages less than or equal to 5%.

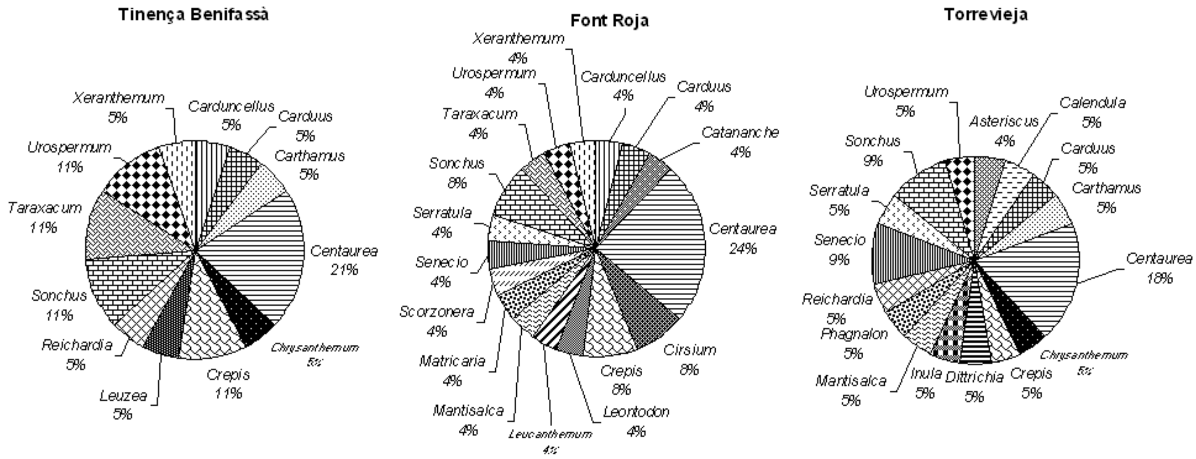

Figure 6-5. Relative importance of the number of mined plant species within each botanical genus in the Compositae family.

The same study in Leguminosae family highlights the presence of great number species of *Medicago* and *Vicia* in all Natural Parks. “Tinença de Benifassà” is composed in greater extent by *Medicago* (23%), *Vicia* (18%) and *Lathyrus* (17%). “Font Roja” by *Medicago* (28%), *Vicia* (12%) and *Cytisus* (12%). While in “Lagunas de La Mata-Torrevieja” the greatest representation is composed by *Medicago* and *Vicia* (both 29%). The percentages cited allow us to know the relative importance of the number of mined plant species within each Natural Park when the number of genera breakdown is equal to or approximately the same.

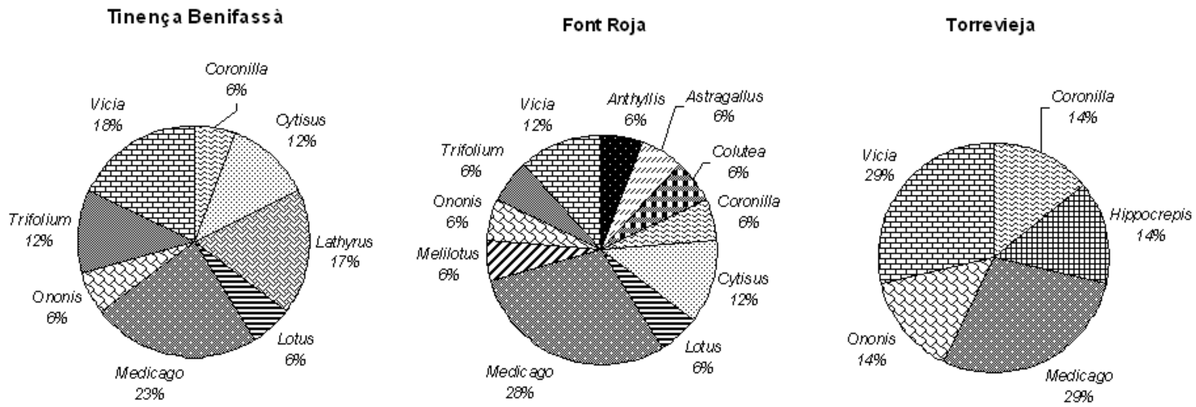

Figure 6-6. Relative importance of the number of mined plant species within each botanical genus in the Leguminosae family.

Cruciferae family is represented in Figure 6-6. The largest biodiversity composition belongs to *Sysimbrium* with four species, two common to “Font Roja” and “Lagunas de La Mata-Torrevieja”. The rest genera are composed by a only botanical species listed in Table 4. It is observed a less number of genera composition than Compositae and Leguminosae family.

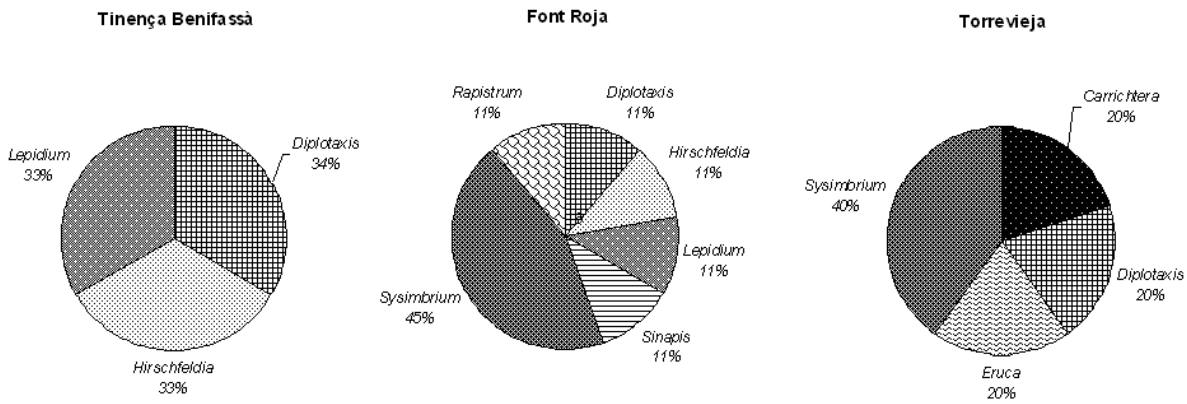

Figure 6-7. Relative importance of the number of mined plant species within each botanical genus in the Cruciferae family.

The largest number of plant species mined in the family Graminae belongs to the *Avena* genus with relative percentages estimated around to 40% in "Font Roja", and 49% in "Lagunas de La Mata-Torrevieja". The total number of species belonging to *Avena* are five, three common to "Font Roja" and "Lagunas de La Mata-Torrevieja". The rest number of genera are represented by a only botanical species listed in Table 6-4.

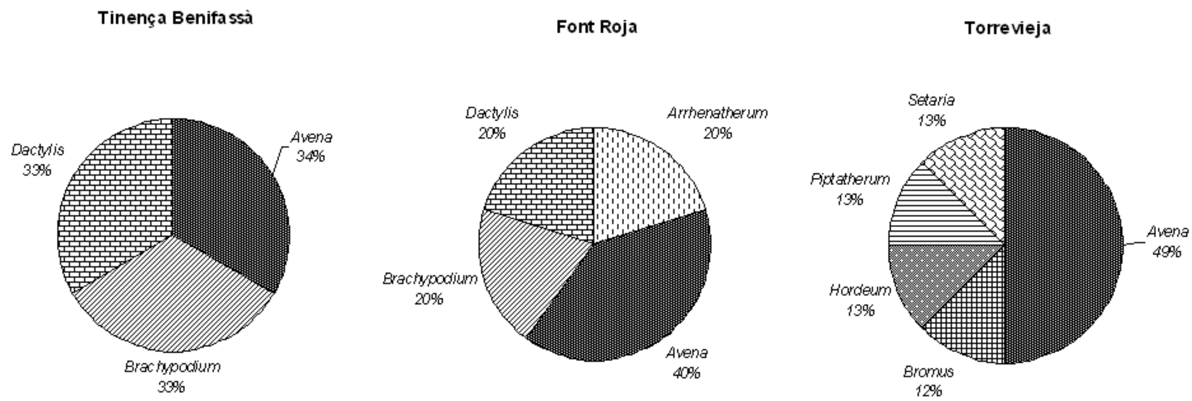

Figure 6-8. Relative importance of the number of mined plant species within each botanical genus in the Graminae family.

Figures 6-8, 6-9 and 6-10 compares the distribution of infestation percentage for each botanical genus from each locality. The results represented are based in the Tables 2 and 3. Thus, it is represented only the interactions which the miners were obtained. Percentages are in function of the number of botanical species mined, and the number of miners Agromyzidae associated to each botanical genera. The Compositae, Leguminosae, and Cruciferae families were broken down because they have the largest representation of mined species.

Figure 6-9 represents the distribution of infestation percentage on Compositae family. The genera greater infested have been *Sonchus* and *Centaurea*, common in all three localities studied. The genera *Crepis* (16%), *Taraxacum* (11%) and *Catananche* (11%) are the other greater genera infested in "Font Roja". In Torrevieja highlights *Urospermum* (13%).

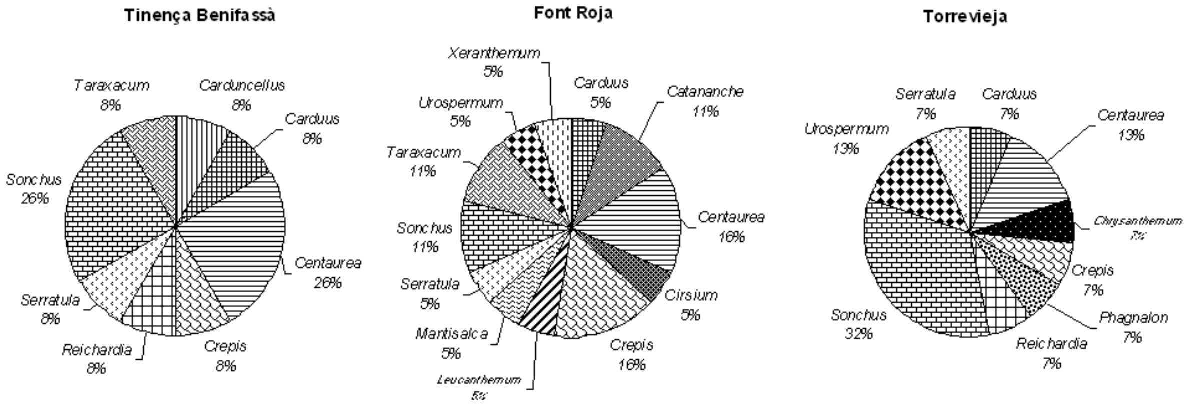

Figure 6-9. Percentage of genera infestation on Compositae family in Tinença de Benifassà, Font Roja and Lagunas de La Mata-Torrevieja.

Distribution of infestation genera on Leguminosae is showed in the figure 6-10, being practically focused on *Vicia*, with a percentage of 67% in “Lagunas de La Mata-Torrevieja” and 33% in “Tinença de Benifassà”. In the same sense, *Medicago* is greatly represented in “Font Roja” (66%) and “Tinença de Benifassà” (34%).

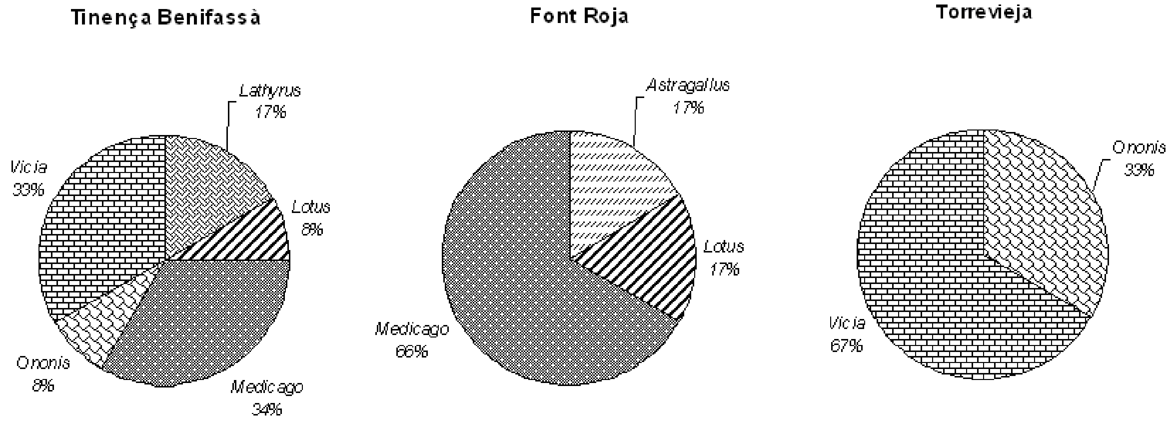

Figure 6-10. Percentage of genera infestation on Leguminosae family in Tinença de Benifassà, Font Roja, and Lagunas de La Mata-Torrevieja.

In Cruciferae family (Fig. 6-11), *Sysimbrium* presents infestation percentages estimated around 50% in “Font Roja” and “Lagunas de La Mata-Torrevieja”. In “Tinença de Benifassà” highlights *Diplotaxis* (60%), and in “Lagunas de La Mata-Torrevieja” cover 25% of mined species. *Lepidium* shows a relative infestation in “Tinença de Benifassà” and “Font Roja”, with a 20% (equal to *Hirschfeldia*) and 27% respectively.

Figures 6-12, 6-13 and 6-14 compare the percentage distribution of miners on Compositae, Leguminosae, and Cruciferae families. The results represented are based in the Tables 2 and 3.

Compositae is by far the largest family of dicotytedons and 164 botanical genera supports the largest number of agromyzids. It is known 302 Agromyzidae species in the family, and the two largest world genera include *Phytomyza* with 86 species, and *Liriomyza* with 76, including 11 polyphagous species.

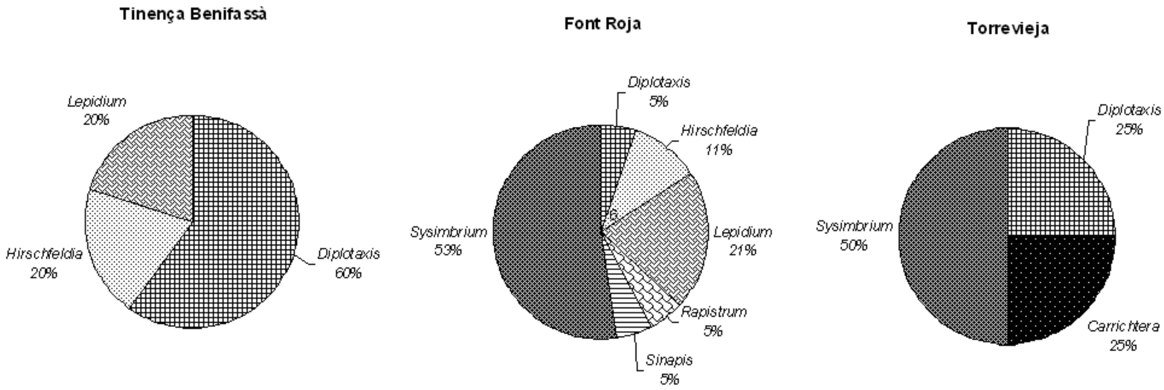

Figure 6-11. Percentage of genera infestation on Cruciferae family in Tinença de Benifassà, Font Roja and Lagunas de La Mata-Torrevieja.

According to Figure 6-12, the leaf-miner with the most degree of participation is *Chromatomyia horticola* in all three localities, with a percentage share of over 60%. In second place, *Ophiomyia beckeri* presents a rate of approximately 25% in all localities. Lower presence of other miners as the monophagous *A. (Amauromyza) carlinae* (leaf-miner of *Cirsium vulgare*) are showed. The presence of *Liriomyza trifolii*, typical of horticultural crops, indicates a strong anthropical pressure on the Natural Park due to the presence of greenhouses relatively close to the sampling area.

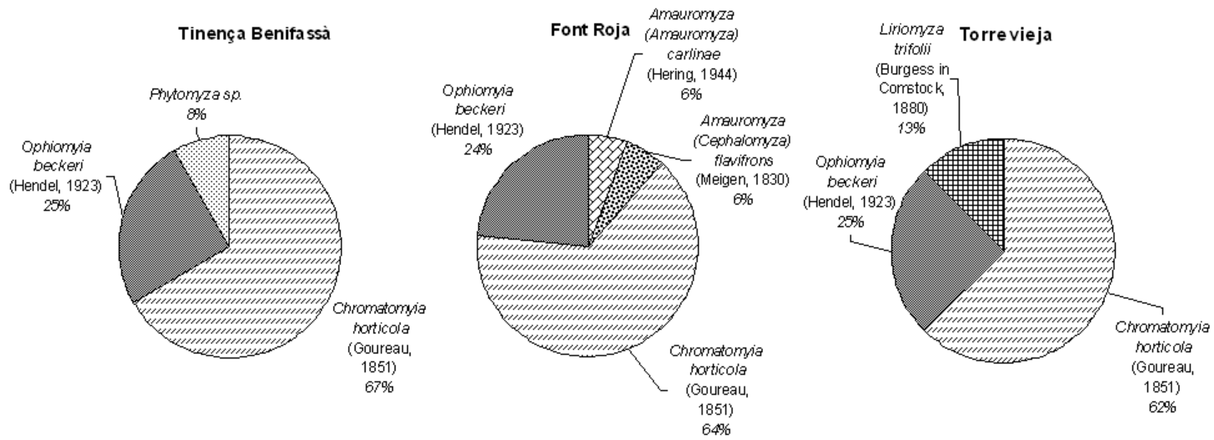

Figure 6-12. Percentage distribution of miners on Compositae in Tinença de Benifassà, Font Roja, and Lagunas de La Mata-Torrevieja.

Fifteen genera of Agromyzidae species are present on the Leguminosae and include tree-borers, gall-causers, stem-borers, stem-miners, seed- and root-feeders, one species feeding in young green thorns, with the majority being leaf-miners. Spencer (1990) cites 106 species of agromyzids known to be colonized on Leguminosae. Of the 106 species on the Leguminosae, 75% are restricted to a single tribe, 14% are oligophagous and 11% are polyphagous. In Europe, the most highly oligophagous species in the family was *Liriomyza congesta*, which is known on 27 genera.

Liriomyza congesta leaf-miner have the largest presence in all three parks studied, constituting 100% in “Lagunas de La Mata-Torrevieja”. *Ophiomyia ononidis*, *Chromatomyia horticola* and *Liriomyza cicerina* show less percentages of infestation estimated around 17% (Fig. 6-13).

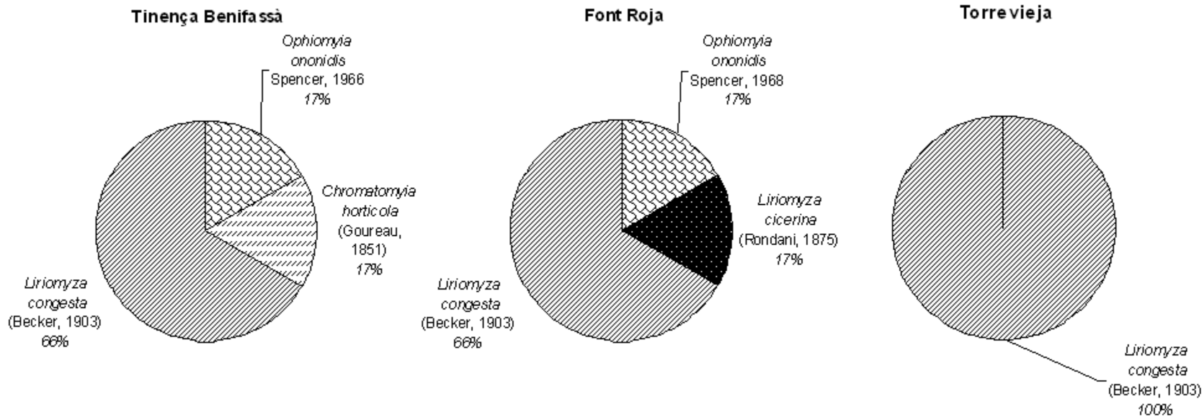

Figure 6-13. Percentage distribution of miners on Leguminosae in Tinença de Benifassà, Font Roja and Lagunas de La Mata-Torrevieja.

The family Cruciferae consists of 350 genera and 3000 plant species. Of the 18 species of Agromyzidae which have successfully adapted to the in general effectively repellent chemistry of this family, ten are family-specific, two also feed on Capparaceae and seven are polyphagous.

Figure 6-14 shows *Liriomyza brassicae* and *Chromatomyia horticola* as miners of great potential of infestation in the three Natural Parks, being the two species with greater presence on Cruciferae. *Liriomyza strigata* with 40% in "Tinença de Benifassà" equals to *Liriomyza brassicae*, while in "Font Roja" represents a 11%.

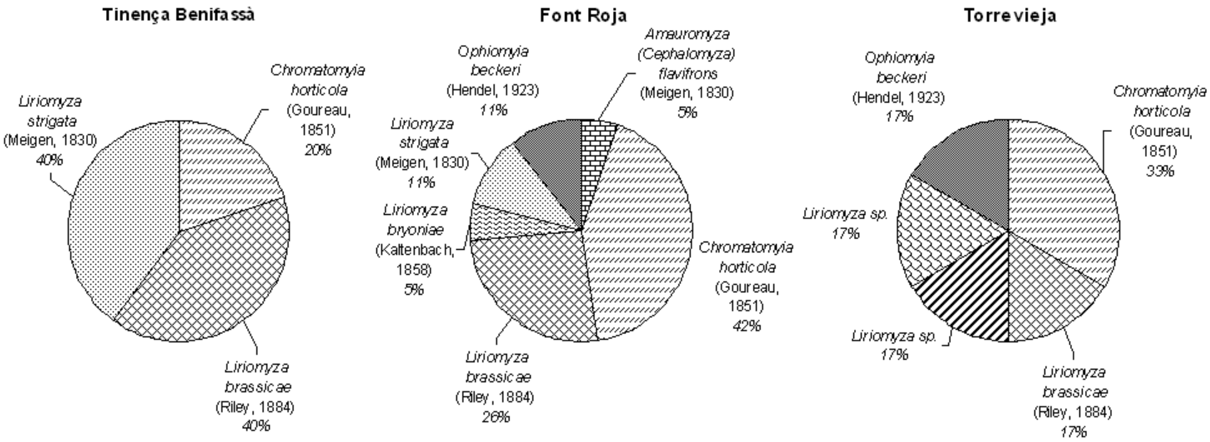

Figure 6-14.Percentage distribution of miners on Cruciferae in Tinença de Benifassà, Font Roja, and Lagunas de La Mata-Torrevieja.

Other species present in "Font Roja" as *Liriomyza bryoniae*, *Ophiomyia beckeri* or *Amauromyza (Cephalomyza) flavifrons* not exceed 10%. In "Lagunas de La Mata-Torrevieja", two unspecific *Liriomyza* species and *Ophiomyia beckeri* equals in percentage to *Liriomyza brassicae*.

Tables 6-6, 6-7 and 6-8 compares the percentage distribution of miners on the rest of botanical families don't studied above. The results represented are based in the Tables 6-2 and 6-3.

Table 6-6 shows the distribution of leaf-miners infestation on other botanical families in “Tinença de Benifassà”. It emphasizes the presence of *Chromatomyia horticola* on *Echium*, *Knautia*, *Scabiosa*, *Papaver*, and *Plantago*. Other polyphagous species such as *Liriomyza brassicae*, and *Liriomyza strigata* are also present. It appears monophagous species as *Phytomyza hellebori*, *Phytomyza plantaginis*, *A. (Amauromyza) balcanica* and *Liriomyza pascuum*.

Families	Genera	Miners	Infestation
Boraginaceae	*Echium*	***Chromatomyia horticola***	100%
Caryophyllaceae	*Dianthus*	***Liriomyza dianthicola***	100%
	Silene	***Liriomyza brassicae***	100%
Chenopodiaceae	*Chenopodium*	***A. (Cephalomyza) karli***	100%
Dipsacaceae	*Knautia*	***Chromatomyia horticola***	66.6%
		Liriomyza strigata	33.3%
	Scabiosa	***Chromatomyia horticola***	100%
Euphorbiaceae	*Euphorbia*	***Liriomyza pascuum***	100%
Labiatae	*Phlomis*	***A. (Amauromyza) balcanica***	100%
Papaveraceae	*Papaver*	***Chromatomyia horticola***	100%
Plantaginaceae	*Plantago*	***Chromatomyia horticola***	66.6%
		Phytomyza plantaginis	33.3%
Ranunculaceae	*Helleborus*	***Phytomyza hellebori***	100%
Solanaceae	*Lycopersicon*	***Liriomyza strigata***	100%

Table 6-6. Percentage distribution of miners on the rest of botanical families in Tinença de Benifassà.

Table 6-7 shows the distribution of the infestation percentage in “Font Roja”. It highlights the presence of *Chromatomyia horticola*, appearing *A. (Cephalomyza) flavifrons* on *Catananche* and *Silene*; and *A. (Amauromyza) morionella* on *Marrubium*.

Families	Genera	Miners	Infestation
Boraginaceae	*Cynoglossum* *Lithospermum*	***Chromatomyia horticola***	100%
Caprifoliaceae	*Lonicera*	***Chromatomyia horticola***	100%
Caryophyllaceae	*Silene*	***A. (Cephalomyza) flavifrons***	66,6%
		Chromatomyia horticola	33,3%
Gentaniaceae	*Blackstonia*	***Chromatomyia horticola***	100%
Labiatae	*Marrubium*	***A. (Amauromyza) morionella***	100%
Malvaceae	*Malva*	***Chromatomyia horticola***	100%
Papaveraceae	*Papaver*	***Chromatomyia horticola***	100%
Plantaginaceae	*Plantago*	***Phytomyza plantaginis***	100%
Primulaceae	*Anagallis*	***Chromatomyia horticola***	100%
Resedaceae	*Reseda*	***Chromatomyia horticola***	50%
		Liriomyza brassicae	50%

Table 6-7. Percentage distribution of miners on the rest of botanical families in Font Roja.

The same study in “Lagunas de La Mata-Torrevieja” reveals the presence of *Pseudonapomyza atratula* on oats, specie with unknown host-plants until now. *Chromatomyia horticola* remains the kind of polyphagous with the greatest presence in the rest of genera sampled.

Families	Genre	Miners	Infestation
Boraginaceae	*Echium*	***Chromatomyia horticola***	100%
Convolvulaceae	*Convolvulus*	***Chromatomyia horticola***	100%
Graminae	*Avena*	***Chromatomyia horticola***	33.3%
		Pseudonapomyza atratula	66.6%
	Piptatherum	***Pseudonapomyza sp.***	100%
Papaveraceae	*Papaver*	***Chromatomyia horticola***	100%
Plantaginaceae	*Plantago*	***Phytomyza plantaginis***	33.3%
		Chromatomyia horticola	66.6%
Scrophulariaceae	*Bellardia*	***Liriomyza sp.***	100%

Table 6-8. Percentage distribution of miners on the rest of botanical families in Lagunas de La Mata-Torrevieja.

Annexes

The additional list to the catalogue of the host-plants of the world Agromyzidae (BENAVENT-CORAI *et al.,* 2005) is presented below. It is included 27 new interactions for science broken down by miners and botanical families (Annexe I and II). The botanical families listed are Caryophyllaceae Juss., Chenopodiaceae Vent., Compositae Giseke (Asteraceae), Cruciferae Juss. (Brassiceae), Gentianaceae Juss., Gramineae Juss. (Poaceae), Leguminosae Juss. (Fabaceae) and Primulaceae Batsch ex Borkh. They highlight the plant-genera *Anagallis* L., *Catananche* L., *Mantisalca* Cass., *Phagnalon* Cass., *Scabiosa* L. and *Urospermum* Scop. reported like new for Agromyzidae. Also an important endemism of Font Roja natural park, *Centaurea rouyi* Coincy, is reported like new host-plant of *O. beckeri*. According to the list added the host-genera of the catalogue of host-plants of the world for Agromyzidae reach the figure of 926.

The Agromyzidae miners listed report species of economic importance like *Chromatomyia horticola*, *Liriomyza brassicae*, *L. cicerina*, *L. orbona*, *L. trifolii* and *Napomyza lateralis* (Benavent *et al*., 2004). These include important species typical of greenhouses (CABELLO *et al.*, 1990 and MORENO *et al.*, 1993) that use the wild flora like reservoirs for their development when crops are not present. Avoiding the alternative flora of Agromyzidae is key to succesful in the pest control.

An important effort have to be done for knowing all host-plants for Agromyzidae of the world. In fact we have constated the presence of a total of 153 interactions established in 94 genera belonging to 27 botanical families in overall study carried out in the three natural parks. The problem of obtaninig the miners from plants makes that a wide range of host-plants of Agromyzidae lack of known miners. Also the difficult of female identifications make that a lot specimens remain identified only at genera level.

Annexe I : Additional list of Agromyzidae species and their host-plants

***AMAUROMYZA* Hendel, 1931**

Subgenus *CEPHALOMYZA* Hendel, 1931

Genera and Species	Distribution	Host-plants Genera
***Am. (Ceph.) flavifrons* (Meigen, 1830)**	**Nea, P**	*Catananche, Lepidium*
***Am. (Ceph.) karli* (Hendel, 1927)**	**Nea, P**	*Chenopodium*

***CHROMATOMYIA* Hardy, 1849**

Genera and Species	Distribution	Host-plants Genera
***Chr. horticola* (Goureau, 1851)**	**Afr, Nea, Ori, P**	*Anagallis, Avena, Blackstonia, Catananche, Mantisalca, Phagnalon, Scabiosa, Serratula, Urospermum, Xeranthemum*

***LIRIOMYZA* Mik, 1894**

Genera and Species	Distribution	Host-plants Genera
***L. brassicae* (Riley, 1884)**	**Afr, Aus, Nea, Neo, Ori, P**	*Diplotaxis, Silene*
***L. cicerina* (Rondani, 1875)**	**P**	*Medicago*
***L. orbona* (Meigen, 1830)**	**P**	*Hordeum*
***L. trifolii* (Burgess in Comstock, 1880)**	**Afr, Aus, Nea, Neo, Ori, P**	*Urospermum*

***NAPOMYZA* Westwood, 1840**

Genera and Species	Distribution	Host-plants Genera
***N. lateralis* (Fallén, 1823)**	**Nea, P**	*Urospermum*

***OPHIOMYIA* Bražnikov, 1897**

Genera and Species	Distribution	Host-plants Genera
***O. beckeri* (Hendel, 1923)**	**Afr, Ori, P**	*Centaurea, Lepidium, Reichardia, Sysimbrium, Urospermum*
***O. ononidis* Spencer, 1966**	**P**	*Lotus*

***PSEUDONAPOMYZA* Hendel, 1920**

Genera and Species	Distribution	Host-plants Genera
***P. atratula* Zlobin, 2002**	**P**	*Avena*

The abbreviation used to indicate the biographic areas are as follows (Benavent-Corai *et al.*, 2005): Afr = Afrotropical (or Ethiopian) region; Aus = Australian region; Ori = Oriental region; P = Palaearctic region; Nea = Nearctic region and Neo = Neotropical region.

Annexe II : Additional list of host-plants and Agromyzidae associated

CARYOPHYLLACEAE Juss.

Host-plants genera	Agromyzid species
***Silene* L.**	*Liriomyza brassicae*

CHENOPODIACEAE Vent.

Host-plants genera	Agromyzid species
***Chenopodium* L.**	*Amauromyza (Cephalomyza) karli*

COMPOSITAE Giseke (Asteraceae)

Host-plants genera	Agromyzid species
***Catananche* L.**	*Amauromyza (Cephalomyza) flavifrons, Chromatomyia horticola*
***Centaurea* L.**	*Ophiomyia beckeri*
***Mantisalca* Cass**	*Chromatomyia horticola*
***Phagnalon* Cass.**	*Chromatomyia horticola*
***Reichardia* Roth.**	*Ophiomyia beckeri*
***Serratula* L.**	*Chromatomyia beckeri*
***Urospermum* Scop.**	*Chromatomyia horticola, Napomyza lateralis, Ophiomyia beckeri*
***Xeranthemum* L.**	*Chromatomyia horticola*

CRUCIFERAE Juss. (Brassiceae)

Host-plants genera	Agromyzid species
***Diplotaxis* DC.**	*Liriomyza brassicae*
***Lepidium* L.**	*Amauromyza (Cephalomyza) flavifrons, Ophiomyia beckeri*
***Sysimbrium* L.**	*Ophiomyia beckeri*

GENTIANACEAE Juss.

Host-plants genera	Agromyzid species
***Blackstonia* Hudson.**	*Chromatomyia horticola*

GRAMINEAE Juss. (Poaceae)

Host-plants genera	Agromyzid species
***Avena* L.**	*Chromatomyia horticola, Pseudonapomyza atratula*
***Hordeum* L.**	*Liriomyza orbona*

LEGUMINOSAE Juss. (Fabaceae)

Host-plants genera	Agromyzid species
***Lotus* L.**	*Ophiomyia ononidis*
***Medicago* L.**	*Liriomyza cicerina*

PRIMULACEAE Batsch ex Borkh.

Host-plants genera	Agromyzid species
***Anagallis* L.**	*Chromatomyia horticola*

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6.4 *Liriomyza*–wild plant interactions (Diptera: Agromyzidae) in mediterranean ecosystems

Abstract The handling of the vegetation cover is known as one of the major cultural strategies in pest control. This study shows the interactions between *Liriomyza* and their host-plants found in three Natural Parks from the Community of Valencia for 6 of the 13 *Liriomyza* species (Diptera: Agromyzidae) cited from Spain as potential pests for agriculture: *L. bryoniae* (Kaltenbach, 1858), *L. cicerina* (Rondani, 1875), *L. congesta* (Becker, 1903), *L. strigata* (Meigen, 1830), *L. brassicae* (Riley, 1884), and *L. trifolii* (Burgess *in* Comstock, 1880). Three new interactions for science to *L. brassicae* and *L. trifolii* are recorded. The importance of these interactions lies in the potential of being able to act as plant reservoirs for development of pest species alternative to crops. Distribution of *Liriomyza* species by botanical families and species, including the study of beta diversity for the studied biotopes, are showed.

Key words: Diptera, Agromyzidae, *Liriomyza*, host-plants, plant-insect interaction, Spain.

Introduction

The species richness of *Liriomyza* (Diptera: Agromyzidae) in Spain is reduced to 37 species from a total of 123 species cited in Europe (MARTINEZ, 2004).

The resume of *Liriomyza* species with agronomic importance in Palaearctic region is listed in MARTINEZ (1993). The equivalent list from Spain is composed by 13 species : *L. brassicae* (Riley, 1884), *L. bryoniae* (Kaltenbach, 1858), *L. cepae* (Hering, 1927), *L. cicerina* (Rondani, 1875), *L. congesta* (Becker, 1903), *L. dianthicola* (Venturi, 1949), *L. flaveola* (Fallén, 1823), *L. huidobrensis* (Blanchard, 1926), *L. orbona* (Meigen, 1830), *L. pusilla* (Meigen, 1830), *L. strigata* (Meigen, 1830), *L. trifolii* (Burgess *in* Comstock, 1880) and *L. xanthocera* (Czerny *in* Czerny & Strobl, 1909).

Forty percent of the literature cited of Agromyzidae is dedicated to genus *Liriomyza*, and more than half of it to their control. During the last decade it has tended to the use of alternative methods to chemical control of the agromyzids. In the most recent bibliography it is cited the use of biological control (TRAN *et al.*, 2007; HO & UENO, 2007; HONDO & KOIKE *et al.*, 2006; HESAMI *et al.*, 2006), the improvement of genetic resistance (ZAHIRI *et al.*, 2006; SHARMA & PAMPAPATHY, 2006), the use of pathogenic microorganisms (TAGAMI *et al.*, 2006; HAGIMORI *et al.*, 2006), the application of plant extracts (REN *et al.*, 2006; HOSSAIN & POEHLING, 2006a), the management of fertilization (PARRELLA & COSTAMAGNA, 2006), or the use of trapping systems (GONCALVES, 2006; AL-AYEDH & AL-DOGHAIRI, 2006).

Reservoirs based on alternative wild plants to crops are one of the cultural methods applied to crop protection. The great versatility of Agromyzidae species facilitate their development on a wide range of plants, estimating that less than 0.6% of the world Agromyzidae species (near 2800 in total) are polyphagous because they are able to develop on several botanic genera of wild and cultivated plants (SPENCER, 1990; BENAVENT-CORAI *et al*., 2005).

Only 50% of the plant-Agromyzidae interactions of worldwide species are known. Getting to investigate the host-plants of the pest species for a given region is necessary to establish preventive measures of control or to support other curative measures.

The aim of this study is to clarify what miner species of the genus *Liriomyza* are present in several natural areas of the Community of Valencia, and the identification of host-plants on which they are rearing.

Materials and methods

Sampling areas

Sampling was carried out throughout the years 2006-2007 in three Natural Parks of the Community of Valencia. Several sampling areas were established within each Natural Park, with a maximum of 7-10 representative points. Location has been characterized through a 38 Channels GPS system. The sampled space for each point was estimated around 100 m of radius.

Locality	Code Point	GPS	High (m)
"Tinença de Benifassà"	TB1	N40º39'22.6"E00º09'26.8"	755
	TB2	N40º40'05.8"E00º08'25.9"	740
	TB3	N40º39'51.3"E00º08'30.0"	727
	TB4	N40º39'31.4"E00º07'46.5"	783
	TB5	N40º39'18.9"E00º09'08.9"	712
	TB6	N40º39'44.5"E00º10'58.5"	721
	TB7	N40º39'48.9"E00º10'21,4"	710
"Font Roja"	FR1	N38º39'43.1"W00º31'04.0"	1076
	FR2	N38º39'40.5"W00º33'09.8"	1177
	FR3	N38º39'27.0"W00º33'40.7"	1222
	FR4	N38º39'33.2"W00º32'31.4"	1299
	FR5	N38º39.49'4"W00º31'54.4"	1081
	FR6	N38º39'46.6"W00º31'32.9"	1071
	FR7	N38º39'53.9"W00º32'20.8"	1054
"Lagunas de La Mata-Torrevieja"	TRV1	N38º01'19.7"W00º40'54.2"	6
	TRV2	N38º01'35.6"W00º41'21.1"	2
	TRV3	N38º01'48.8"W00º42'00.1"	5
	TRV4	N38º01'56.6"W00º42'19.7"	4
	TRV5	N38º01'57.2"W00º42'37.9"	4
	TRV6	N38º01'56.9"W00º42'43.0"	9
	TRV7	N38º01'15.7"W00º43'49.1"	6
	TRV8	N38º01'38.8"W00º41'27.5"	5
	TRV9	N38º01'56.6"W00º42'09.4"	4
	TRV10	N38º01'57.2"W00º42'37.9"	5

Table 1. Table summary of GPS locations.

Description of sampling areas

Tinença de Benifassà: it is characterized as little anthropic locality, having been declared Natural Park in 2007. It has hot summers and cold winters. The annual precipitation averages are estimated around 450-500 mm. It has typically Mediterranean scrub vegetation combined with pine and oak (predominantly *Quercus ilex* L.) forests. Its altitude ranges between 700 and 800 m a.s.l. (above sea level).

Font Roja: Natural Park located at North of Alicante province. It consists of deciduous forests where several species of *Quercus* are predominant. It presents high temperatures in summer, with frequent snowfalls in winter, and annual rainfall averages estimated around 350-450 mm. It is situated in a mountain system between 1000-1300 m a.s.l.

Lagunas de La Mata-Torrevieja: the Natural Park of “Lagunas de La Mata-Torrevieja” has vegetation of salt marshes combined with forests of *Pinus halepensis* Mill. Rainfall is very low (<300 mm per year) doing that in may the high temperatures have done away with virtually all fresh flora. It is located between 2-9 m a.s.l.

Sampling

Sampling work has been conducted weekly by visual detection of damages produced by agromyzids on vegetation throughout the period of 2 years. Damage is observed due to the presence of mines in leaves and stems of wild plants.

Miners were obtained after emergency from attacked plants maintained from collection into controlled environment chambers, at temperature of 25-26ºC and humidity of 65-70%. The samples were revised every 2 days, and the specimens obtained were preserved for study in ethyl alcohol 70º.

Agromyzidae species were identified by means of the morphological study of the genitalia in males, and the external characters of females. Finally each Agromyzidae species was associated with its attacked botanical species.

Identifications of all *Liriomyza* species were verified by MICHEL MARTINEZ (cited as an author of this article).

Biodiversity indicators

The biodiversity from the standpoint of comparing the present species between the several localities has been studied. In this sense, the beta diversity considers the rate or degree of change in the composition of species between some communities in a landscape. Therefore, its measurement is based in proportions or differences. Indexes of similarity, dissimilarity or distance, replacement of species and complementarity are related with this diversity.

Indexes provide a replacement value of beta diversity in the biological sense described by WHITTAKER (1972). They are based on qualitative data (presence-absence of species).

Whittaker index: $\beta = \dfrac{S}{\alpha - 1}$

S = Number of species recorded in a set of samples
α = Average number of species in samples

Complementary index measures the degree of difference in species composition between different communities (COLWELL & CODDINGTON, 1994). It is calculated as the percentage of unique species of a community:

Complementarity: $$C = \frac{S_A + S_B - 2V_{AB}}{S_A + S_B - V_{AB}} \times 100$$

S_A y S_B = species richness of communities A and B
V_{AB} = number of species in common between two communities

so that,

$$C = \frac{exclusive\,species\ from\ a\,site}{total\,richness\ for\,both\,sites\,combined} \times 100$$

A comparison between pairs of samples, complementarity and beta diversity have a minimum value of zero when the two communities are identical, and a maximum value of 100 when communities are completely different.

Results and discussion

Agromyzidae-plant interactions

The identified *Liriomyza* species and their association with locality and host plant species are shown in Table 2.

It has been obtained 6 of the 13 species of *Liriomyza* recorded from Spain as potential agriculture pests. Three interactions are new for science: *Liriomyza brassicae* on *Diplotaxis erucoides* and *Silene vulgaris*, as well as *Liriomyza trifolii* on *Urospermum picroides*. Distribution of *Liriomyza* is not uniform, since three species are present in only one of the Natural Parks and two of them are common to the three studied parks.

Agromyzidae species	Locality	Plant species
Liriomyza brassicae	TB	*Diplotaxis erucoides* L. (*)
	TB, FR	*Hirschfeldia hincana* (L.)
	FR	*Lepidium draba* L.
	TB	*Silene vulgaris* (Moench) (*)
	FR, TRV	*Sysimbrium irio* L.
	FR	*Sysimbrium officinale* (L.)
	FR	*Sysimbrium orientale* L.

Liriomyza bryoniae	FR	*Sysimbrium irio* L.
Liriomyza cicerina	FR	*Medicago sativa* L.
Liriomyza congesta	FR	*Astragallus sesameus* L.
	TB	*Lathyrus aphaca* L.
	TB	*Lathyrus latifolius* L.
	FR	*Lotus corniculatus* L.
	TB, FR	*Medicago lupulina* L.
	TB, FR	*Medicago sativa* L.
	TB	*Ononis spinosa* L. subsp. *australis* (Sirj.)
	TB	*Vicia hirsuta* (L.)
	TB	*Vicia hybrida* L.
	TB, TRV	*Vicia sativa* L.
	TRV	*Vicia villosa* Roth
Liriomyza strigata	TB	*Diplotaxis erucoides* L.
	TB	*Knautia rupicola* (Willk.)
	TB, FR	*Lepidium draba* L.
	TB	*Lycopersicon esculentum* Mill.
	FR	*Sysimbrium orientale* L.
Liriomyza trifolii	TRV	*Sonchus tenerrimus* L.
	TRV	*Urospermum picroides* (L.) (*)

(*) New host-plants interactions.

Table 2. Table summary of Agromyzidae-plant interactions.

Plant distribution

Distribution of botanical families affected by *Liriomyza* in the Natural Park of "Tinença de Benifassà" is shown in Figure 1. Families which have been affected in a greater number of species are Leguminosae (53.33%) and Cruciferae (26.67%). Subsequent families Caryophyllaceae, Dipsacaceae and Solanaceae have been damaged in fewer proportions (<10%).

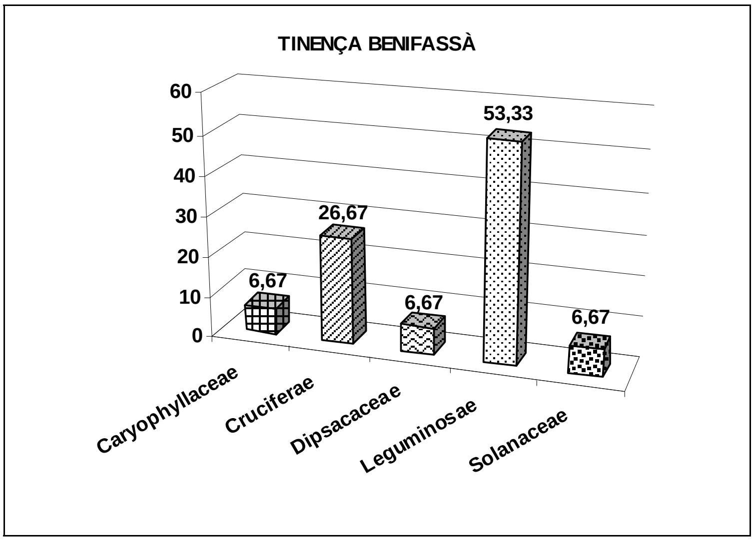

Figure 1. Distribution in percentage of plant families attacked by *Liriomyza* in Natural Park of "Tinença de Benifassà".

Same distribution for the Natural Park of “Font Roja” is shown in Figure 2. Similarly to “Tinença de Benifassà”, the botanical families hardest damaged are Cruciferae (61.64%) and Leguminosae (38.46%) although with a changed order in distribution, being higher in case of Cruciferae. No other botanical families have been affected by *Liriomyza* in this Natural Park.

Three botanical families have been affected in the Natural Park of “Lagunas de La Mata-Torrevieja” (Figure 3): Leguminosae (40%), Compositae (40%) and Cruciferae (20%). The high presence of the family Compositae is focused on only *Sonchus tenerrimus* and *Urospermum picroides*.

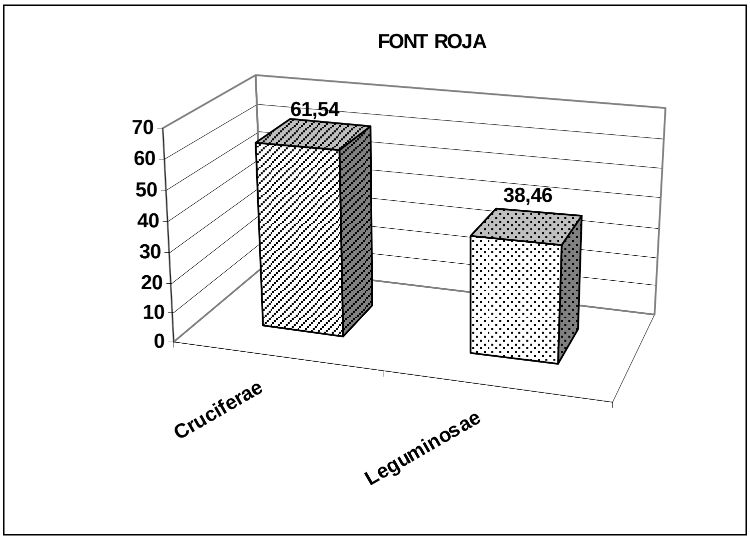

Figure 2. Distribution in percentage of plant families attacked by *Liriomyza* in Natural Park of “Font Roja”.

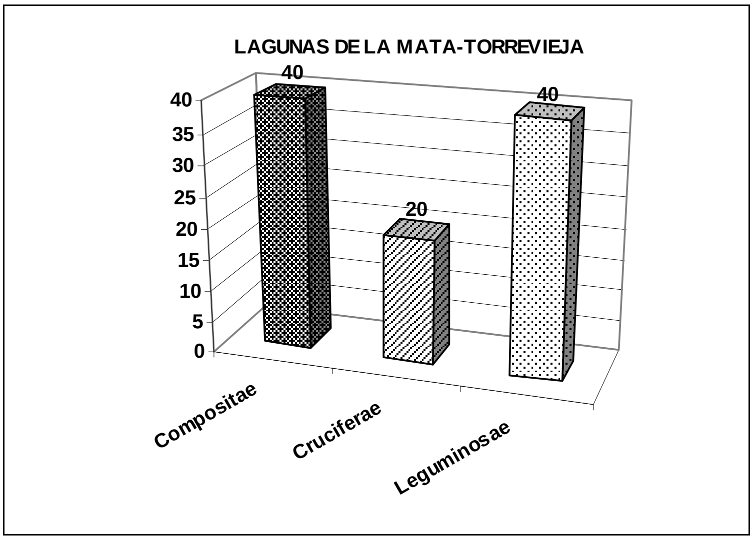

Figure 3. Distribution in percentage of plant families attacked by *Liriomyza* in Natural Park of “Lagunas de La Mata-Torrevieja”.

Liriomyza distribution

The species distribution of *Liriomyza* present in the Natural Park of "Tinença de Benifassà" (Figure 4) shows that half of the plants mined by *Liriomyza* were attacked by *L. congesta* (53%), being also present *L. strigata* (27%) and *L. brassicae* (20%) both in a lesser extent.

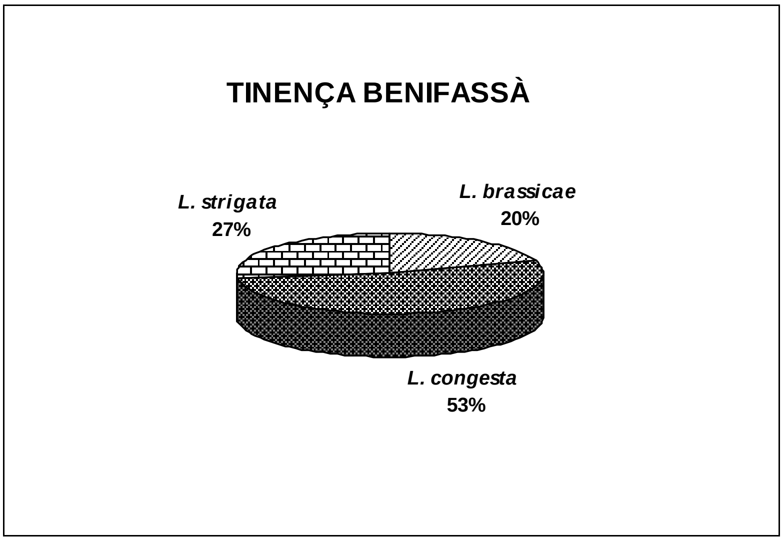

Figure 4. Percentage distribution of *Liriomyza* present in Natural Park of "Tinença de Benifassà".

Five *Liriomyza* species have been collected in the Natural Park of "Font Roja" (Figure 5): *L. brassicae* (38%), *L. congesta* (31%), *L. strigata* (15%), *L. bryoniae* (8%) and *L. cicerina* (8%). The last two species are only present in this park.

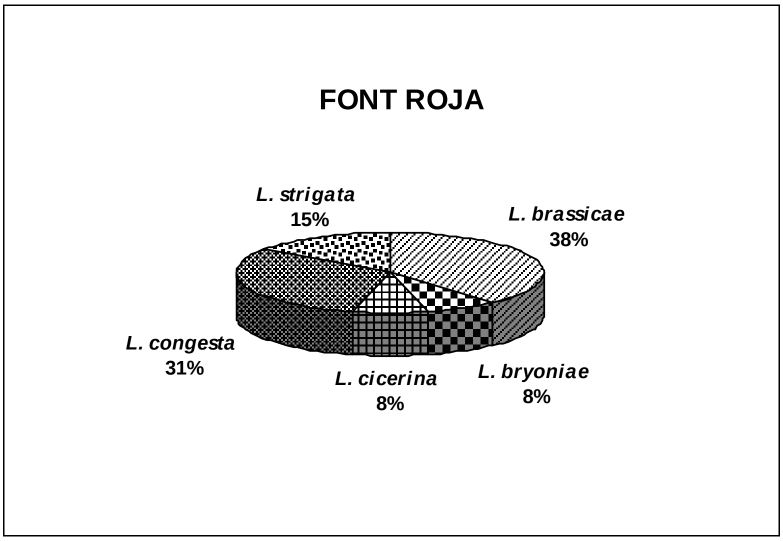

Figure 5. Percentage distribution of *Liriomyza* present in Natural Park of "Font Roja".

The Natural Park of "Lagunas de La Mata-Torrevieja" is represented by 3 *Liriomyza* species (Figure 6): *L. brassicae* (20%) and *L. congesta* (40%), as in case of the other two typically forestal parks, and the exclusive *L. trifolii* (40%). This last species is a leaf miner of horticultural crops, which is in accordance with the strong anthropic pressure on the park by the presence of greenhouses in a radius of less than 5 km.

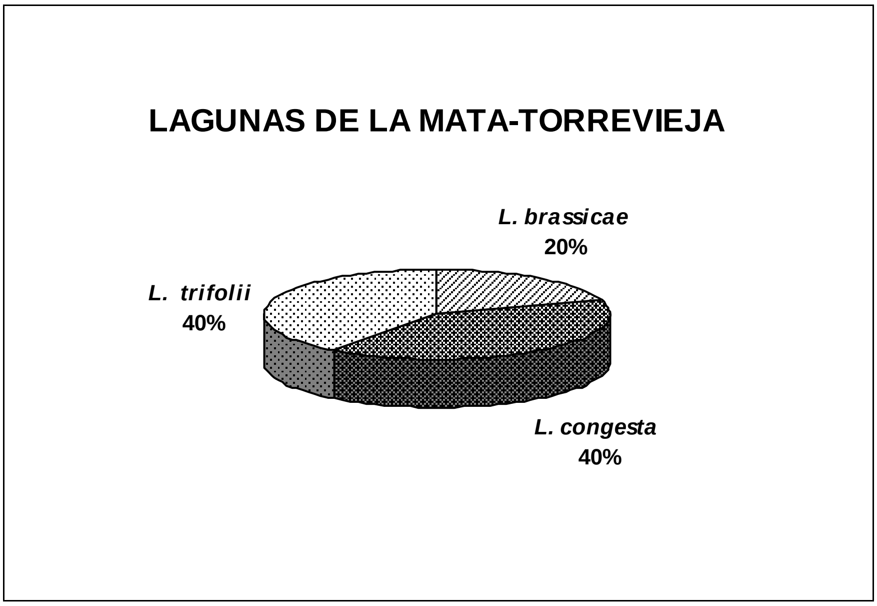

Figure 6. Percentage distribution of *Liriomyza* present in Natural Park of "Lagunas de La Mata-Torrevieja".

Biodiversity study

β Biodiversity	T.Benifassà-Font Roja	T. Benifassà-Torrevieja	Font Roja-Torrevieja	Global
Complementarity	**60%**	**50%**	**85.7%**	**55%**
Whittaker index	**25%**	**33.3%**	**50%**	**63.5%**

Table 3. Table summary of β biodiversity between communities. It indicates the complementarity degree between communities and the index of Whittaker, both expressed in percentage.

Results of the biodiversity study of *Liriomyza* species in the 3 Natural Parks are presented in Table 3. The most similar species distribution is found when they are compared with the Natural Park of "Tinença de Benifassà", showing complementarities around 50% and Whittaker index about 25%. But these indexes increase greatly when they are compared with each other Natural Parks "Font Roja" and Torrevieja. So "Tinença de Benifassà" presents similar species found mostly in the other two Natural Parks, while that "Font Roja" and "Lagunas de La Mata-Torrevieja" present greater differences on species distribution. In fact "Font Roja" has 5 *Liriomyza* species, and Torrevieja presents *Liriomyza trifolii* extremely abundant and not found in the other Natural Parks.

Conclusions

The study throughout 2 years in the cited Natural Parks have informed of the presence of 6 important *Liriomyza* species for the Spanish agriculture. The associations with their host-plants have revealed 3 new interactions for science.

Liriomyza congesta is presented as the miner with the most polyphagy availability in "Tinença de Benifassà" and "Lagunas de La Mata-Torrevieja" and practically also in "Font Roja". *Liriomyza brassicae* and *Liriomyza strigata* are really very present in the majority of wild Cruciferae flora. *Liriomyza trifolii* is specially present in "Lagunas de La Mata-Torrevieja" due to a reflection of the close crops. And finally, other very important species as *Liriomyza bryoniae* and *Liriomyza cicerina* are present in "Font Roja" over Cruciferae and Leguminosae, respectively.

The study of biodiversity indicates the low similarity level between the Natural Parks of "Font Roja" and "Lagunas de La Mata-Torrevieja", because their different richness and species composition. "Tinença de Benifassà" possesses the greatest degree of species complementarities with respect to the other two Natural Parks.

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6.5 Modelling climate effects on the ecological dynamics of *Pseudonapomyza* (Diptera: Agromyzidae) genus

Abstract *Pseudonapomyza* (Diptera: Agromyzidae) genus is one of the main monocots leaf-miners in the southeast of Spain. The relationship between fluctuating temperatures, precipitation and sex-ratio are correlated with the miners phenology by means of the use of Canonical Correlations Analysis, Principal Components Analysis and Multiple Regression Analysis. *Pseudonapomyza* captures were studied throughout three years of Malaise trap sampling in the natural parks of "Tinença de Benifassà", "Font Roja", and the "Lagunas de La Mata-Torrevieja" in the Community of Valencia. Population growth is proportional to fluctuation of the temperatures with a 79,87% of significance, and the precipitation does not seem to affect directly to the captures. Maximum thresholds of average temperature are established around 20-25ºC in "Tinença de Benifassà" and "Lagunas de La Mata-Torrevieja", while that 30-35ºC occurs in the case of "Font Roja". Globally, the largest *Pseudonapomyza* populations in "Tinença de Benifassà" are recorded in late May and early June with captures about 20 males/week. In "Font Roja" the highest male populations are set at around 17-19 males/week in June and July. The behavior in the natural park of "Lagunas de La Mata-Torrevieja" is different to that observed in the other two. The high temperatures, upper than 40, recorded in summer destroy all broadleaf plants from mid-may, being maximum populations recorded in autumn with 8-10 males/week. The modelling of climate effects is presented as a tool for understanding the fluctuation of captures and the establishment of prevent measures of pest control in an appropriate way.

Key Words Diptera, Agromyzidae, *Pseudonapomyza*, climate, phenology, population dynamics, ecology, Spain.

Introduction

The lack of prevention and evaluation models of climate influence on the ecological dynamics within Agromyzidae (Diptera) makes that control measures are carried out randomly without any objective criteria or once damages over plants are present. These questions normally produce the reduction of crop yields and the increasing of production costs (FITZ-EARLE & HOLM, 1983, WILHOIT *et al.*, 1991, BELCARI *et al.*, 2000, RASPI, 2000). Within Agromyzidae modelling is only presented in *Liriomyza* genus with the study of the overwintering limits (CHEN & KANG, 2005b). Some other examples into different families of flies include the fruit fly *Ceratitis capitata* (Wiedemann, 1824) (GEVREY & WORNER, 2006), the cherry fruit fly *Rhagoletis indifferens* Curran, 1932 (SONG *et al.*, 2003), the fruit fly *Bactrocera tryoni* (Froggatt, 1897) (YONOW *et al.*, 2004), the Drosophilidae flies (WARREN *et al.*, 2003), and the Chloropidae flies (LINDBLAD, 2001). The aim of this study is the use of statistical tools to establish the correlation between the environmental variables of temperature and precipitation with male presence, female presence and sex-ratio of *Pseudonapomyza* genus. Proposed models will allow a better understanding of the genus bioecology from the Eastern area of Spain for supporting the control of present and future pests. Knowing the specific periods in which these miners appear and the environmental conditions that favour their development will permit us to anticipate the damage over the plants.

Within Agromyzidae family the phenology works associated with the insect-weather relation are focused mainly on *Liriomyza* and *Melanagromyza* genera. DURAIRAJ (2007) studied the behavior of *Liriomyza trifolii* (Burgess in Comstock, 1880) watching a positive association of these flies with maximum and minimum temperatures and sunshine hours. By contrast, they showed a negative association with relative humidity, rainfall and rainy days. CHEN & KANG (2005a) investigated the cold tolerance of a laboratory-reared population and latitude-separated populations of the leaf-miner *Liriomyza sativae* Blanchard, 1938 in terms of low-temperature survival rate and supercooling capacity, highlighting the importance of minimum temperatures in distribution of populations. CHEN *et al.* (2002) and KANG *et al.* (2009) stress the importance of extreme temperatures in survival and the supercooling point of *Liriomyza* genus. In *Melanagromyza*, SUBHARANI & SINGH (2007) and AKHILESH & PARAS (2004) studied the effects of temperature, relative humidity, rain, sunshine and wind speed on the population build up of the pigeonpea pod fly *Melanagromyza obtusa* (Malloch, 1914), highlighting the negative effects of relative humidity with the pest infestation.

Generally flies are poikilothermic, being the temperature the main physical factor that determines the metabolic reactions (MASAKI, 1980; GILBERT & RAWORTH, 1996), and precipitation is considered the main factor implied in the regulation of relative humidity (GLIESSMAN, 1998) crucial for survival of immature stages (HAO & KANG, 2001). So that, effects of temperature and precipitation are studied to explain the evolution of population dynamics.

The sex-ratio determines the presence of reproductive periods and indicates the time at which the populations will increase. These periods are associated with climatic factors particularly the temperature (FRAENKEL & GUNN, 1940). Knowing the levels of sex-ratio at which populations grow beyond the threshold of economic damage is another tool that allows us to anticipate pests.

Pseudonapomyza genus includes important pests around the world. Overall ninety-two species are spread across most of the geographical regions except South America (ZLOBIN, 2002). At the level of Palaearctic region forty-four species are known, and in Spain the presence of seven species is described (MARTÍNEZ & BÁEZ 2002): *Pseudonapomyza atra* (Meigen, 1830), *Ps. hispanica* Spencer, 1973, *Ps. insularis* Zlobin, 1993, *Ps. lacteipennis* (Malloch, 1913), *Ps. spinosa* Spencer, 1973, *Ps. strobliana* Spencer, 1973, and *Ps. vota* Spencer, 1973. BENAVENT-CORAI *et al.* (2004) cites as species of economic interest in Spain *Ps. atra* (Meigen, 1830) and *Ps. spinosa* Spencer, 1973. Cereals genera with the most agronomic importance susceptible of being mined by *Pseudonapomyza* genus in Spain are *Avena*, *Secale*, and *Triticum* (BENAVENT-CORAI *et al.* 2005). Nineteen host-plants of *Pseudonapomyza* genus are known to be included in monocots: Poaceae (10); Asterids: Acanthaceae (7), Asteraceae (1); and other Eudicots: Amaranthaceae (1). In temperate zones of Northern and Southern hemispheres *Pseudonapomyza* mines exclusively on monocots (SPENCER, 1990). In the Mediterranean region this vegetation appears when the temperatures begin to rise dramatically from late spring when the presence of broadleaf plants begins to decrease.

Materials and Methods

Capture system. Captures were obtained using the Malaise trap capture system (Model G700, Entomopraxis-Barcelona-Spain) developed by RENÉ EDMON MALAISE in 1937, demonstrating with broad effectiveness in monitoring the evolution of populations of Agromyzidae flies (von-TSCHIRNHAUS, 1992), throughout the years 2004 to 2006. The GPS system (38 channels receiver) was used to localize the traps. The captures were collected weekly, except in periods of snow risk in which the traps were removed. 70 vol alcohol was used for the conservation of collected specimens. We performed the specimens sexing, their quantitative assessment and their specific identification.

The presence of a subcostal vein extremely short compared to the rest of Agromyzidae specimens, as well as the characteristic pointed antenna (ZLOBIN, 2002) were the main diagnostic characters used to separate specimens of the genus *Pseudonapomyza*.

Sampling zones. Studied areas belong to protected areas declared Natural Parks in the Community of Valencia. The parks studied were chosen based on their different bioclimatic and faunistic factors: “Tinença de Benifassà” (Castellón), “Font Roja” (Alcoy-Alicante) and the “Lagunas de La Mata-Torrevieja” (Alicante) (Fig. 6-15). Characterization of the Malaise traps location areas are listed in Table 6-9.

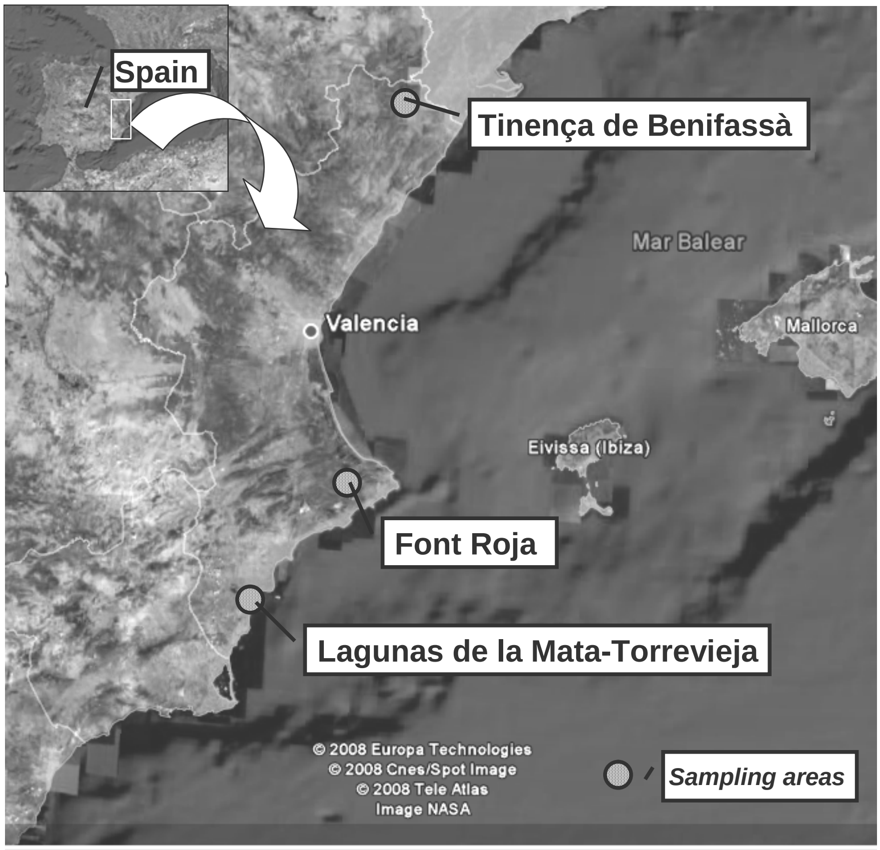

Figure 6-15. Geographical location of the South-Eastern Iberian peninsula indicating the location zones of Malaise traps used in the capture of *Pseudonapomyza* specimens.

Code	Natural Park	Locality	Altitude	GPS Coordinates	Orography
TN	“Tinença de Benifassà”	Castellón	755	N40º39'22.6" / E00º09'26.8"	Mountain
FR	“Font Roja”	Alicante	1076	N38º39'43.1" / W00º31'04.0"	Mountain
TRV	“Lagunas de La Mata-Torrevieja”	Alicante	5	N38º01'48.8" / W00º42'00.1"	Salt marsh

Table 6-9. Characterizing parameters of the Malaise traps location areas in each of the Natural Parks studied.

Climate characterization. Climatic characterization of the parks was carried out by obtaining climate data from the weather stations closest to the areas of study. Figs. 6-16, 6-17 and 6-18 show the evolution of maximum/minimum temperature (°C), and precipitation (l/m^2) throughout the three years of study in the reservoir of Ulldecona-Castellon (550m a.s.l.) (representative of “Tinença de Benifassà”), in Bocairent-Alicante (880m a.s.l.) (representative of “Font Roja”), and in Torrevieja-Alicante (representative of the “Lagunas de La Mata-Torrevieja”) (1m a.s.l.).

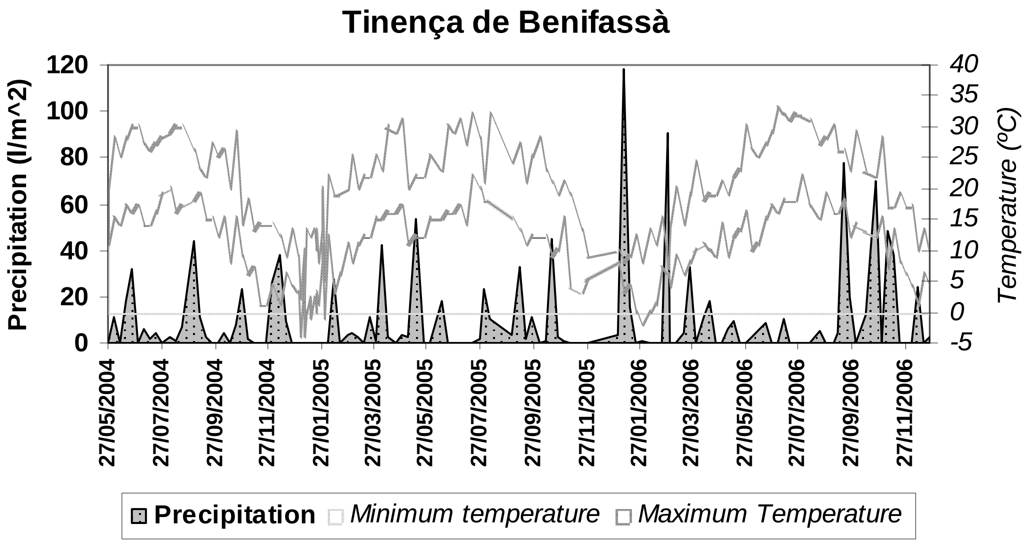

Figure 6-16. Evolution of temperatures and precipitations inside the Natural Park of “Tinença de Benifassà”.

Table 6.10 shows the average temperatures and precipitations in “Tinença de Benifassà”, “Font Roja” and “Lagunas de La Mata-Torrevieja”. It is noted that the average temperatures of the “Lagunas de La Mata-Torrevieja” are around of 3-6 ºC higher than the other two parks studied that show quite similar average temperatures. Highest rainfall is located in a different way in each locality: in “Tinença de Benifassà” is focused mainly in spring (28.53 ± 3.63 l/m^2) and autumn (21.27 ± 8.03 l/m^2), in “Font Roja” is presented primarily in autumn (18.00±10.34 l/m^2) and winter (28.72 ± 16.58 l/m^2), while the low rainfall recorded in the “Lagunas de La Mata-Torrevieja” is produced mainly in autumn (15.09 ± 7.56 l/m^2) and spring (9.57 ± 9.37 l/m^2).

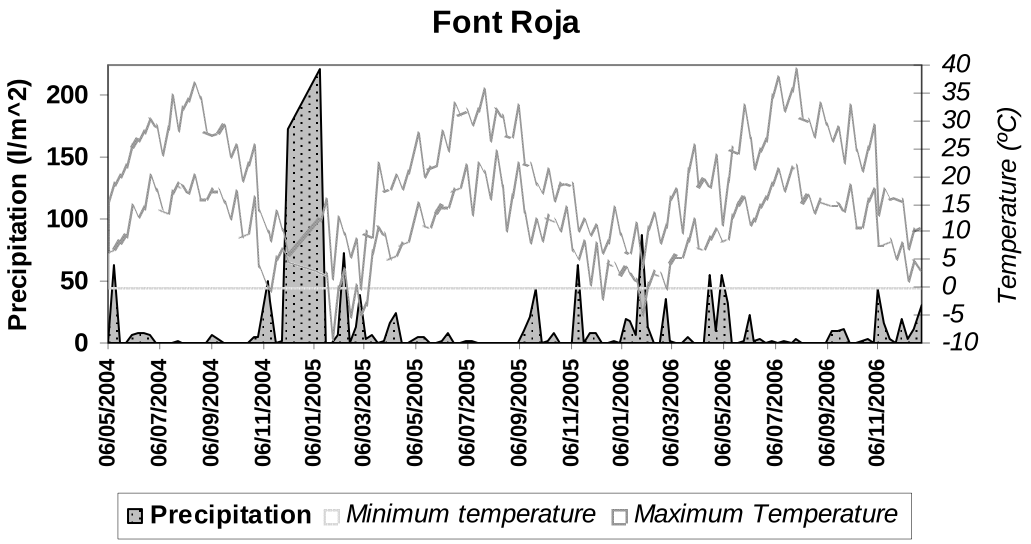

Figure 6-17. Evolution of temperatures and precipitations inside the Natural Park of “Font Roja”.

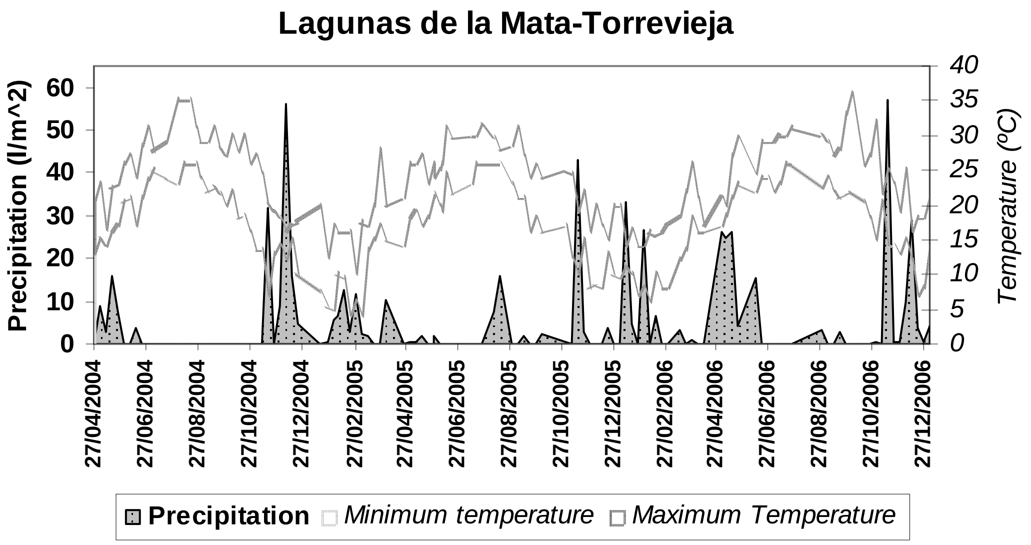

Figure 6-18. Evolution of temperatures and precipitations inside the Natural Park of “Lagunas de La Mata-Torrevieja”.

	Average temperature (ºC)			Precipitation (l/m^2)		
	TN	**FR**	**TRV**	**TN**	**FR**	**TRV**
Spring	18,33 ± 1,99def	16,59 ± 0,18cde	21,90 ± 0,43fg	28,53 ± 3,63abc	14,17 ± 9,24abc	9,57 ± 9,37abc
Summer	22,19 ± 0,72fg	23,44 ± 0,12g	26,52 ± 0,66g	14,98 ± 5,42abc	5,57 ± 3,92ab	3,77 ± 4,28a
Autumn	13,66 ± 1,02cde	13,02 ± 1,66bc	19,22 ± 2,16ef	21,27 ± 8,03abc	18,00 ± 10,34bc	15,09 ± 7,56 abc
Winter	9,11 ± 0,95ab	7,03 ± 1,49a	13,40 ± 1,23bcd	9,42 ± 0,99	28,72 ± 16,58c	6,80 ± 2,05abc

Values followed by the same letter are not significantly different at the 99% level. The method used to discriminate among the means is Fisher's least significant difference (LSD) procedure. With this method, there is a 1% risk of calling each pair of means significantly different when the actual difference equals 0. ANOVA statistical study of average temperatures and precipitations was done separately. Seasons: spring (beginning 20-21 Mar.), summer (21-22 June), autumn (23-24 Sept.), winter (21-22 Dec.).

Table 6-10. Average temperatures and precipitations with their standard error for each of the parks studied.

Statistical analysis. Captures were basically studied by means of three multivariate methods: Canonical Correlations Analysis (CCA), Principal Components Analysis (PCA), and Multiple Regression Analysis (MRA). Canonical ordinations or constrained ordinations (TER BRAAK, 1986, 1987) allow us to identify the combination of variables that explain better the variation of captures abundance by optimizing the adjustment of the species abundance in a given set of environmental variables (TER BRAAK, 1986, TER BRAAK & PRENTICE, 1988). Canonical techniques require less data and are easier to implement than the regression, besides its results give a much more global vision. Today, the CCA is the technique used by most researchers to solve problems related to the direct analysis of gradient (ZHANG & OXLEY, 1994).

The PCA is another multivariate statistical technique that synthesizes information, or reduces the size (number of variables) losing less information as possible (RAO, 1984). The new principal components or factors will be a linear combination of the original variables, and they will be independent of each other. PCA is meaningless in the case of high correlations between variables, as these are indicative of redundant information and therefore few factors explain much of the total variability.

The MRA refers to techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and several independent variables. This technique is widely used for prediction particularly of forecasting of time-series data.

The statistical analysis was carried out with the software STATGRAPHICS PLUS 5.1 (Statistical Graphics Corp., CPD-UPV, Spain).

Results

Captures phenology. This tool allows us to study the evolution of captures with their temporary representation in the space. The peaks indicate maximum presence in a determined lapse of time. Captures of males and females are studied in the figures separately.

In “Tinença de Benifassà” is noted that the the major number of captures are obtained between late May and early June being quantified around 20-25 males/week (Fig. 6-19). There is a significant seasonality of captures, reaching a maximum when average daily temperatures are around 25ºC. Although the temperatures of the years studied showed a similar trend, the captures in 2004 are much lower. This find out some other factors involved in the captures.

Captures seasonality of *Pseudonapomyza* in the Natural Park of “Font Roja” are represented in Fig. 6-20. Captures variability shows that they are related to climatic conditions like in the Natural Park of “Tinença de Benifassà”. However, there are significant differences in captures without changing the pattern of average temperatures. The minor number of captures were produced between July and September with an estimation of around 8-20 specimens/week.

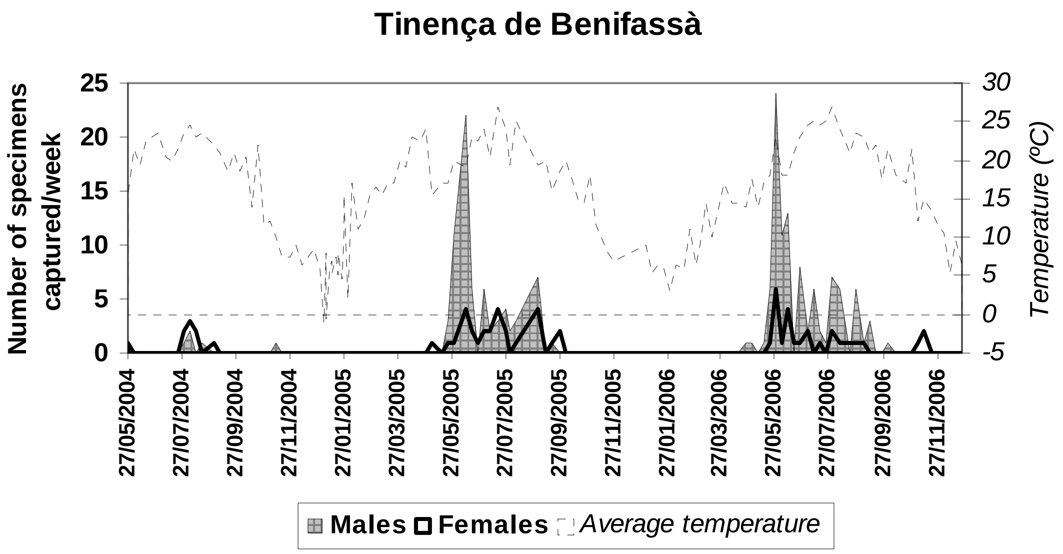

Figure 6-19. Space-time captures evolution of *Pseudonapomyza* genus in the Natural Park of "Tinença de Benifassà".

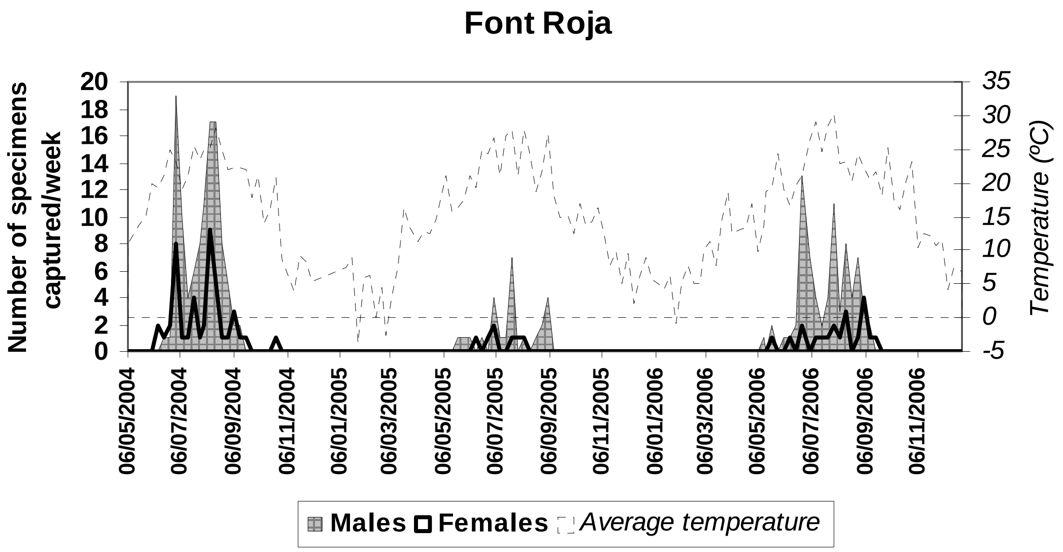

Figure 6-20. Space-time evolution of the captures of *Pseudonapomyza* genus in the Natural Park of "Font Roja".

In the case of the Natural Park of the "Lagunas de La Mata-Torrevieja", it is noted that the seasonality of *Pseudonapomyza* is concentrated in those months that temperature is around 20ºC (Fig. 6-2). Highest temperatures occurring in this nature reserve since late May destroy and impede the development of practically all fresh flora of the place. There is a dominance in the presence of females during the hottest periods.

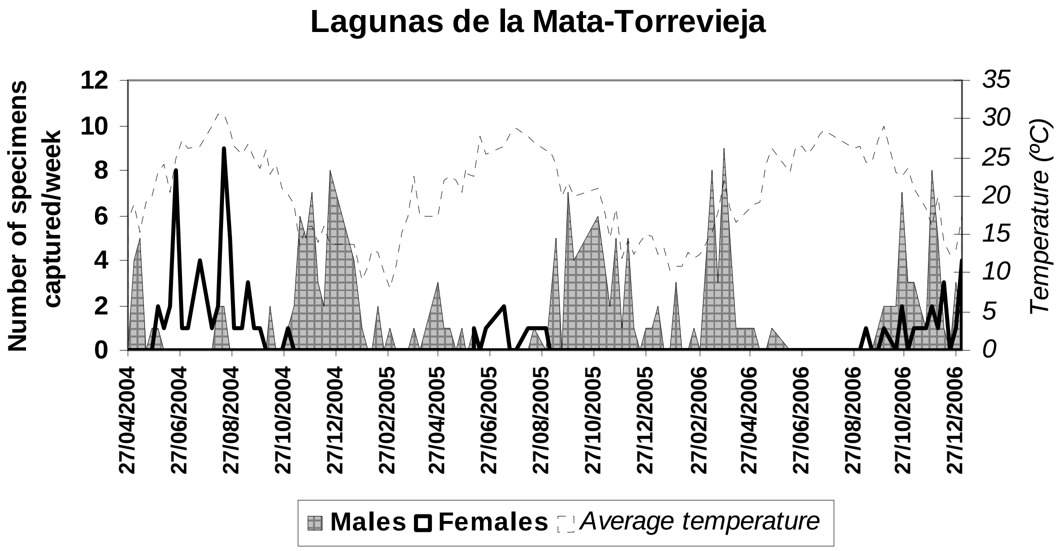

Figure 6-21. Space-time captures evolution of *Pseudonapomyza* genus in the Natural Park of "Lagunas de La Mata-Torrevieja".

	"Tinença de Benifassà"		"Font Roja"		"Lagunas de la Mata-Torrevieja"	
	Males	**Females**	**Males**	**Females**	**Males**	**Females**
Spring	4,20 ± 0,43de	1,30 ± 0,36abc	2,17 ± 1,65ab	1,17 ± 0,26a	2,67 ± 1,86abc	1,38 ± 0,53ab
Summer	2,05 ± 1,51bc	1,05 ± 0,61abc	5,35 ± 2,76e	1,86 ± 0,79abc	2,25 ± 1,39ab	1,18 ± 0,80ab
Autumn	0,06 ± 0,06a	0,16 ± 0,14a	0 ± 0	1 ± 0a	3,69 ± 0,45cd	2,72 ± 0,79abc
Winter	0 ± 0	0 ± 0	0 ± 0	0 ± 0	3,45 ± 0,88abc	1,07 ± 0,12a

Values followed by the same letter are not significantly different at the 99% level. The method used to discriminate among the means is Fisher's least significant difference (LSD) procedure. With this method, there is a 1% risk of calling each pair of means significantly different when the actual difference equals 0. Seasons: spring (beginning 20-21 Mar.), summer (21-22 June), autumn (23-24 Sept.), winter (21-22 Dec.).

Table 6-11. ANOVA table of average captures of males and females indicating the number of specimens captured/week with their standard errors for each of the Natural Parks studied.

Table 6-11 represents the average number of weekly captures in each of the studied areas. Captures of "Tinença de Benifassà" and "Font Roja" are focused almost exclusively on the months of spring and summer. Female captures in both parks oscillate around 1 per week. The male captures in "Tinença de Benifassà" are double in spring than in summer (4,20 ± 0,43 and 2,05 ± 1,51 respectively), whereas in "Font Roja" they are slightly more than double in summer than in spring (5,35 ± 2,76 and 2,17 ± 1,65 respectively). The particular microhabitat of the "Lagunas de La Mata-Torrevieja" means that captures of males and females are constant throughout the year and around the same order, stressing major number of the captures produced in autumn (3,69 ± 0,45 males and 2,72 ± 0,79 females).

Sex-ratio. Sex-ratio indicates the relationship between the presence of males and females in a population. Presence of positive sex-ratio indicates the predominance of male versus female which is a good indicator of reproductive periods. Thus, the seasonal sex-ratio peaks determine the number of annual generations (SCHOLL, 1978). The anticipation to these maximums is key to carry out the measures control of populations.

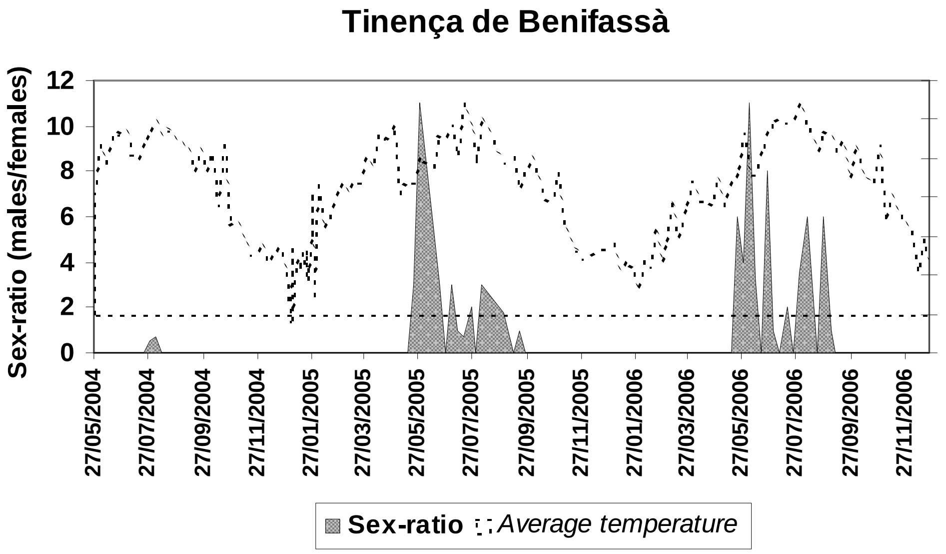

Figure 6-22. Sex-ratio of *Pseudonapomyza* genus captures in the Natural Park of "Tinença de Benifassà".

In Fig. 6-22 is observed the presence of 4-5 generations of *Pseudonapomyza* in the locality of "Tinença de Benifassà" during the years 2005-2006. The highest rates of sex-ratio are produced at the end of May and they are comprised between 10-12.

Sex-ratio captures in the Natural Park of "Font Roja" is represented in Fig. 6-23. The presence of three generations is clearly observed in "Font Roja", which could be 4-5 in some cases. Due to the altitude on which the Malaise Trap is located and within typical vegetation of carrascal making a major number of captures when temperatures rise above 20ºC. This means that in the hottest months of July and August, generations of *Pseudonapomyza* are not so diminished as seen in the case of "Tinença de Benifassà".

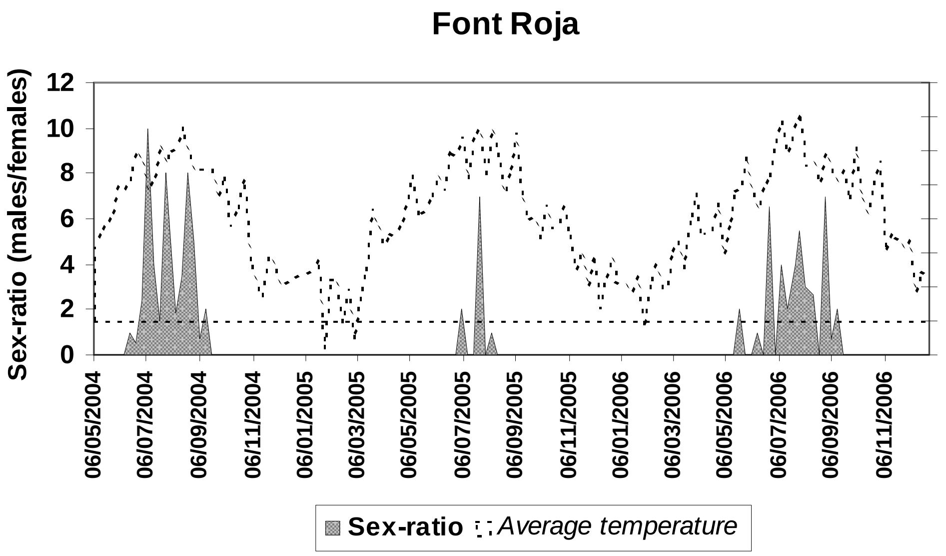

Figure 6-23. Captures sex-ratio of *Pseudonapomyza* genus in the Natural Park of "Font Roja".

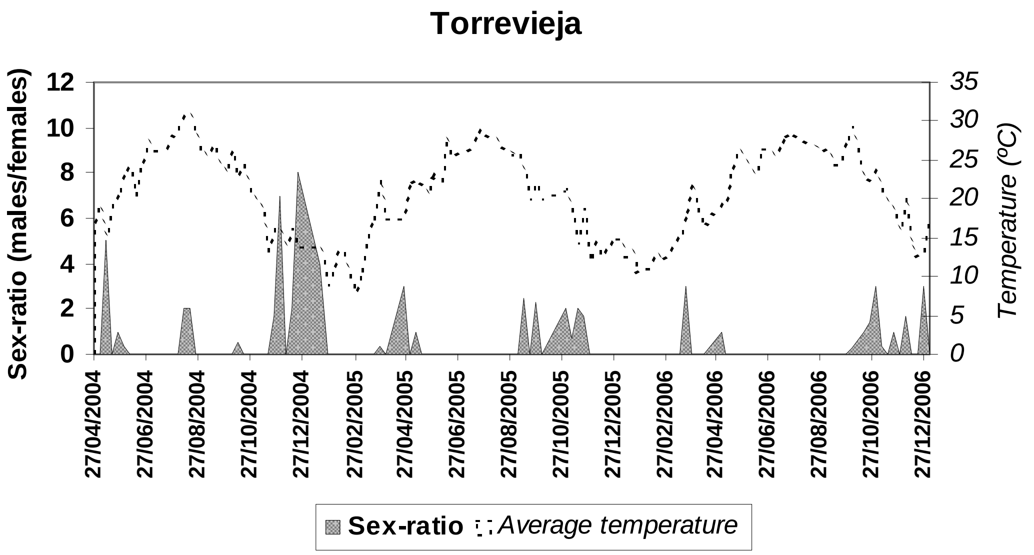

Figure 6-24. Sex-ratio captures of *Pseudonapomyza* genus in the Natural Park of "Lagunas de La Mata-Torrevieja".

Fig. 6-24 shows the seasonality of *Pseudonapomyza* sex-ratio in the nature reserve of "Lagunas de la Mata-Torrevieja". The presence of 2-3 peaks is noted in the spring, and 2 clear peaks in mid-autumn and early winter. The seasonal periods of *Pseudonapomyza* reproduction focus on those in which the average temperature ranges 20-25 ºC, avoiding the heat of summer that in the case of "Lagunas de la Mata-Torrevieja" will come to exceed 40 ºC temperature half a day.

With the objective of knowing the relationship between the sex-ratio of the studied natural parks, an analysis of multiple comparison was undertaken (Multiple Sample Comparison). This will perform several tests and statistical charts that allow a comparison of data in an orderly manner. So that it can find out the presence of significant differences between parks through the analysis of data variance.

Figs. 6-25 and 6-26 show the graphical analysis of variance of sex-ratio data for each of the studied parks. It is noted that the sex-ratios of "Tinença de Benifassà" (3,663 ± 3,045) and "Font Roja" (3,595 ± 2,608) are quite similar and show no significant differences between the two. However, when we compare with sex-ratio of the "Lagunas de La Mata-Torrevieja" (2,156 ± 1,844) significant differences are observed at 95% confidence. These threshold limits inform us the moments when greater reproductive periods are present.

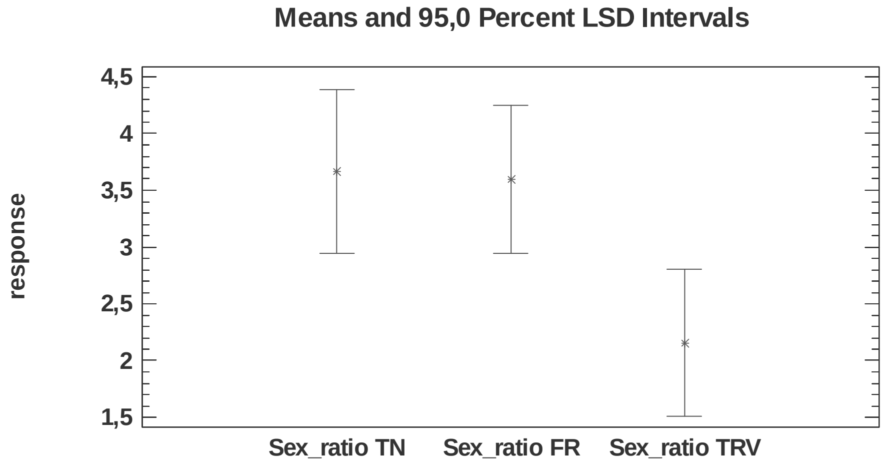

Figure 6-25. Means graphic of sex-ratios studied. Intervals currently displayed are based on Fisher's least significant difference (LSD) procedure. They are constructed in such a way that if two means are the same, their intervals will overlap 95% of the time.

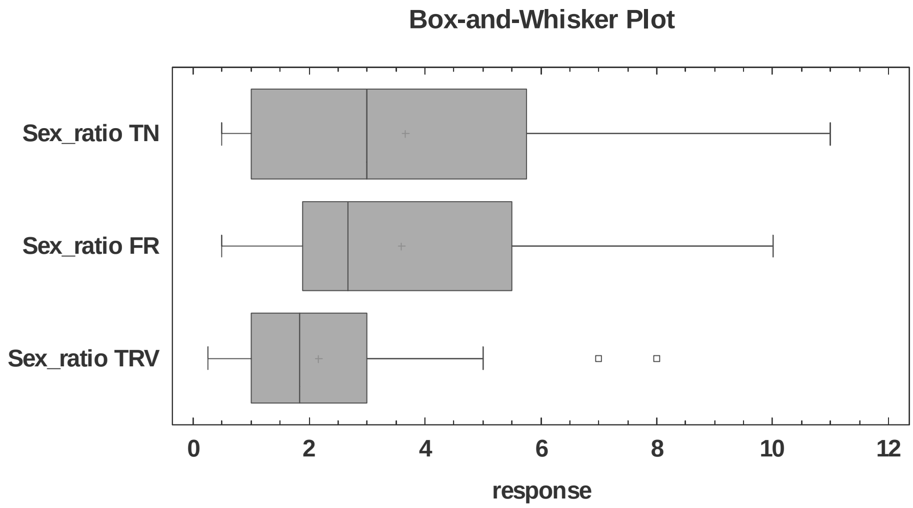

Figure 6-26. Box and Whisker plot of the sex-ratios for each locality studied.

Canonical Correlations Analysis of captures. Overall data has been analyzed in the first instance through a CCA with the aim of establishing the relationships between captures of males and females. This analysis explain the relationship between both groups by setting the lowest number of linear possible combinations.

The results of the CCA between the 2 groups of the studied variables, males and females, show the existence of 3 sets presenting linear combinations. The resultant sets belong to males and females of each of the studied parks. For the first set (males), the first linear combination found is -0,301497 Males TN – 0,933 Males FR + 0,059 Males

TRV, while the second (females) is -0,373 Females TN - Females FR 0,906 - Females 0,038 TRV. The main components belong to Males FR and Females FR, both with negative trend. Male captures in "Tinença de Benifassà" and "Lagunas de La Mata-Torrevieja" present correlations in the same direction, while "Lagunas de La Mata-Torrevieja" moves in the opposite one. Something similar happens in the case of females in which the correlation coefficient of "Lagunas de La Mata-Torrevieja" is very low. The second pair of canonical correlations present the linear combinations 0,945 Males TN - 0,373 Males FR + 0,159 Males TRV and 0,935 Females TN -0,405 Females FR - 0,069 Females TRV. Observations highlight the two variables, Males and Females TN, in a positive sense. On the third pair of canonical correlations the linear combinations established are -0,151 Males TN – 0,047 Males FR + 0,988 Males TRV and -0,092 Females TN -0,165 Females FR -1,013 Females TRV. It is noted that the main factors that make up the correlations are compound of Males TRV variables in a positive sense and Females TRV in negative.

Table 6-12 shows the estimated correlation between each set of canonical variables. The shown 3 p-values are lower than 0.05, the 3 correlations established are significant at a confidence level of 95%. Figure 6-27 shows the cloud of points for the graphic representation of the first canonical correlation established. The existence of linear trends indicates a strong correlation between the different variables.

Canonical Correlations

Number	Eigen value	Canonical Correlation	Wilks Lambda	Chi-Square	D.F.	P-Value
1	0,670	0,818	0,126	263,885	9	0,0000
2	0,556	0,746	0,382	122,616	4	0,0000
3	0,139	0,373	0,861	19,102	1	0,0000

Coefficients for Canonical Variables of the First Set			
Males TN	-0,301	0,945	-0,151
Males FR	-0,933	-0,373	0,047
Males TRV	0,059	0,159	0,988
Coefficients for Canonical Variables of the Second Set			
Females TN	-0,373	0,935	-0,092
Females FR	-0,906	-0,405	-0,165
Females TRV	-0,038	-0,069	1,013

Table 6-12. Statistical table showing the results of the Canonical Correspondence Analysis between males and females of all 3 locations studied. $P<0.05$ denotes the presence of significant correlations with a confidence level of 95%.

The CCA has shown the existence of strong linear relationships between captures of the three studied areas. Captures also differ as per locations and with different ways of growth. Results show a high dependence on the particular conditions of each locality, such as climatology, anthropic pressure, the flora diversity potentially exploitable by *Pseudonapomyza*, the presence of free water, and so on.

Principal Components Analysis of captures dependence. In view of the obtained data, the objective is to explore how climatic variables, temperature and precipitation influence on response of the captures. Knowing in which proportion the studied communities differ depending on their climate would establish an ecological model and would explain the phenology of *Pseudonapomyza* genus in the studied parks.

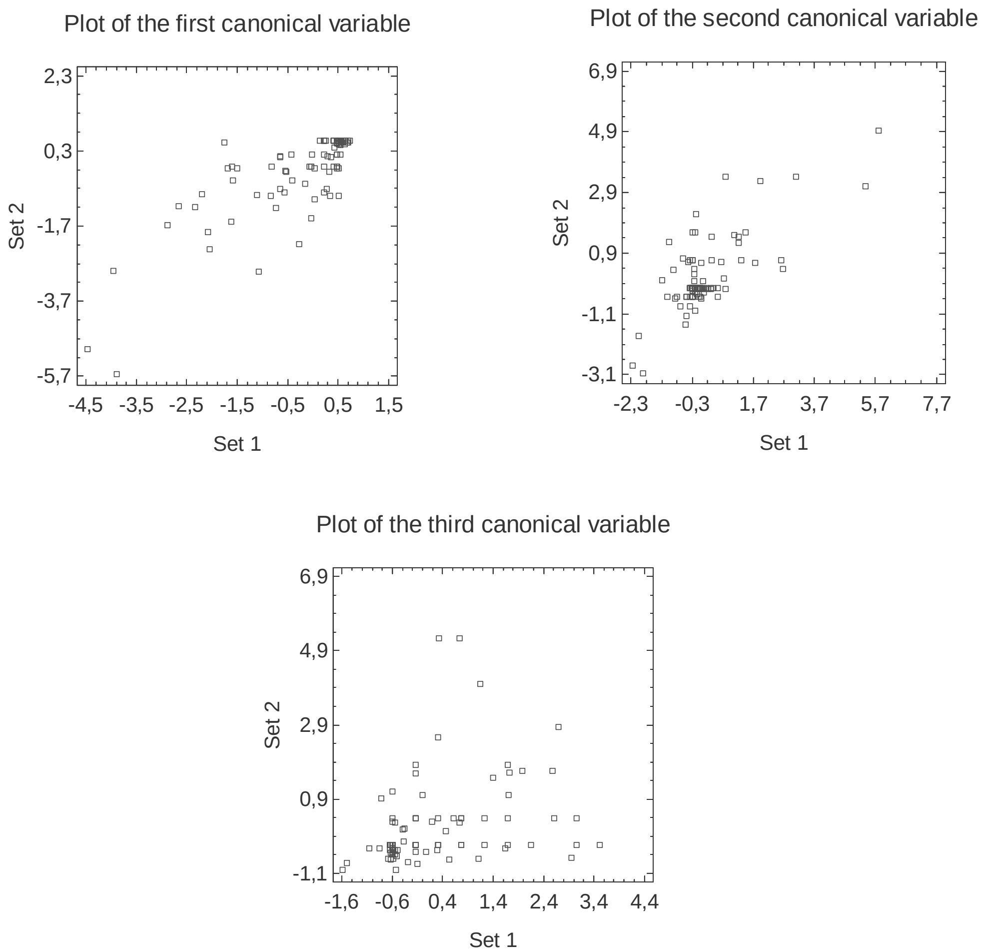

Figure 6-27. Plotting of the three canonical variables studied. Presence of linear trends indicates the strong correlation between males and females of each locality.

In the study the variables used in the PCA have been males (TN, FR, TRV) and females (TN, FR, TRV). Table 6-13 and Fig. 6-28 shows the results of the analysis with the lowest number of combinations of the 6 studied variables. Three components explain the 82.198% of the variability of the studied data, from 1888 components that showed higher values than 1.

Table 6-14 shows the coefficients of the equations of the main components. As an example, the first principal component has the equation 0,387 Males TN + 0,489 Males FR - 0,360 Males TRV + 0,419 Females TN + 0,477 Females FR - 0,280 Females TRV. Where values of variables are standardized by subtracting their average and by dividing their standard deviations.

Principal Components Analysis			
Component number	**Eigen value**	**Percent of variance**	**Cumulative Percentage**
1	2,280	37,997	37,997
2	1,439	23,983	61,981
3	1,213	20,217	82,198
4	0,561	9,342	91,539
5	0,314	5,239	96,778
6	0,193	3,222	100,000

Table 6-13. Statistical table showing the Eigen value, the percentage of variance and the percentage explained of the variance of the captures Principal Component Analysis.

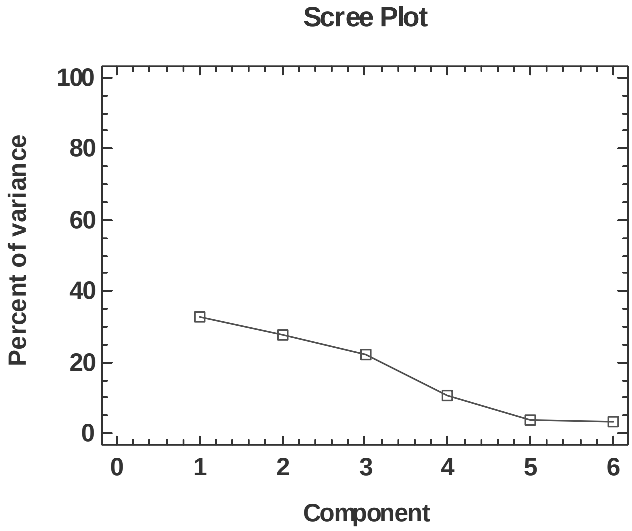

Figure 6-28. Plotting of the percentage of variance for each component result of Principal Component Analysis. The first three components explain 82,198% of the total variability observed in the data.

Table of Component Weights			
	Component 1	**Component 2**	**Component 3**
Males TN	0,387	-0,557	0,221
Males FR	0,489	0,463	0,186
Males TRV	-0,360	0,045	0,575
Females TN	0,419	-0,477	0,307
Females FR	0,477	0,487	0,190
Females TRV	-0,280	0,096	0,675

Table 6-14. Summary of the weight of each one of the variables that make up the 3 components resulting from the Principal Component Analysis.

Figs. 6-29 and 6-30 show the three-dimensional representation of each one of the variables that constitute the components obtained from PCA. It is noted that component 3 is mainly influenced by “Lagunas de La Mata-Torrevieja” captures, component 1 is influenced by “Tinença de Benifassà” captures, and component 2 by “Font Roja” captures. The fact that the captures of males and females evolve in the same direction for every natural park make us think on the close dependence between the captures and the bio-ecological conditions of each place.

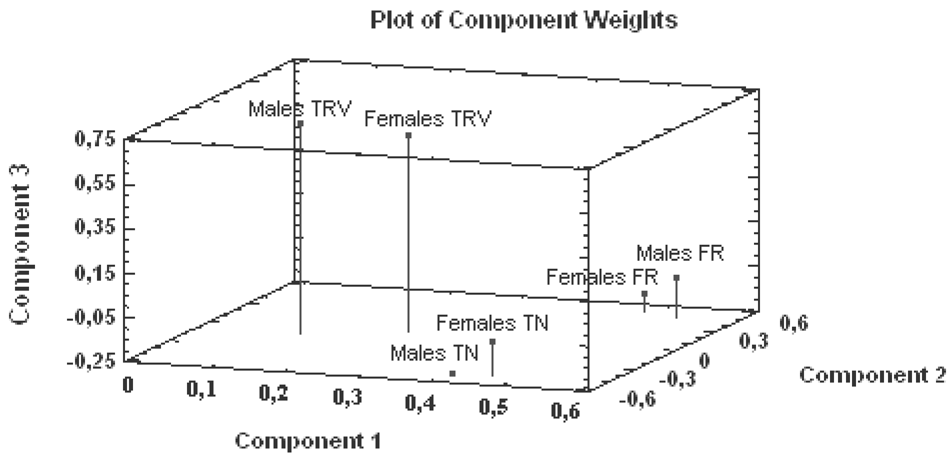

Figure 6-29. Three-dimensional representation that shows the relative weight of each of the variables studied for the three components obtained from the PCA.

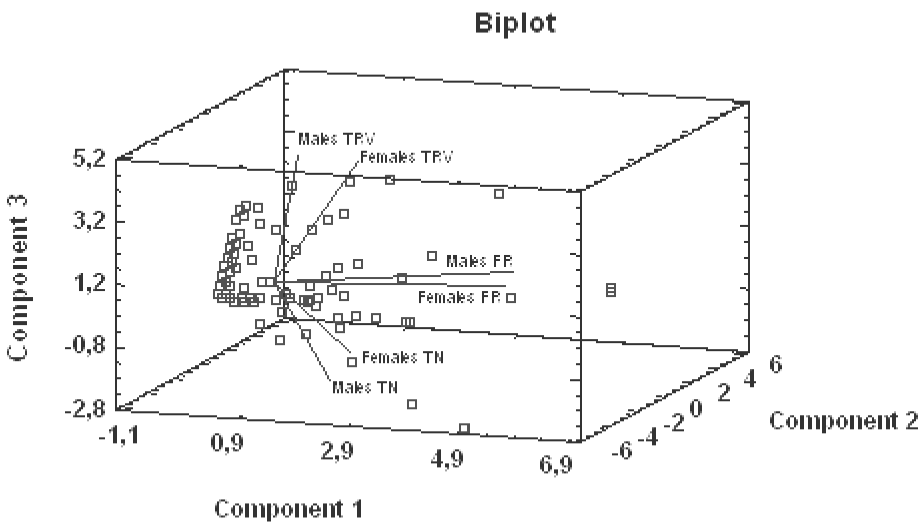

Figure 6-30. Biplot 3D representation that shows the result for each of the variables studied with respect to the components obtained from the PCA.

Correlation between captures and climate variables. It is required in order to estimate the degree of influence of the climatic variables, temperature and precipitation, in the variability of Malaise trap captures. Studying overall captures shows a clear seasonality with the time (Fig. 6-31).

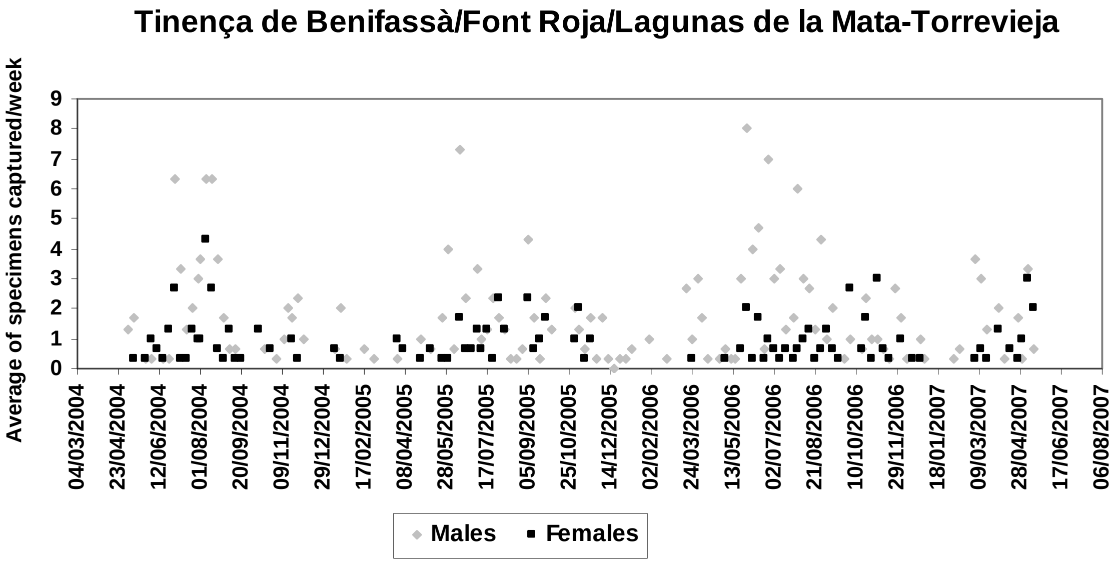

Figure 6-31. Representation of the average of weekly captures for males and females for the three Natural Parks studied. The joint study reflects a seasonality focused primarily in the months of spring and autumn.

To estimate the degree of explanation of captures based on climatic variables of temperature and precipitation, it has been done through a new PCA (Table 6-15) studying each site separately and by including the climatic variables: maximum temperature (T_max), minimum temperature (T_min) and precipitation (Pr). Each of the climate variables has been calculated as the weekly average in line with the weekly captures obtained.

Principal Components Analysis

Component Number	Eigen value			Percent of variance			Cumulative Percentage		
	TN	FR	TRV	TN	FR	TRV	TN	FR	TRV
1	2,557	2,925	2,831	51,146	58,500	56,615	51,146	58,500	56,615
2	1,131	1,072	1,163	22,610	21,433	79,872	73,757	79,933	79,872
3	0,978	0,740	0,504	19,563	14,796	89,945	93,320	94,729	89,945
4	0,247	0,198	0,358	4,942	3,954	97,109	98,262	98,682	97,109
5	0,087	0,066	0,145	1,738	1,318	100	100	100	100

Table of Component Weights

	Component 1			Component 2		
	TN	FR	TRV	TN	FR	TRV
T_max	0,525	0,520	0,549	-0,449	-0,274	0,016
T_min	0,522	0,502	0,545	-0,480	-0,284	0,024
Pr	-0,099	-0,250	-0,412	-0,294	0,614	-0,403
Males	0,449	0,468	-0,478	0,538	0,455	0,290
Females	0,490	0,443	-0,056	0,438	0,510	0,868

Table 6-15. Table summary of the PCA for each of the parks studied. The analysis focuses on the first 2 components that explain the 79,87% of the variability of the observed data.

Two components explain 79.87% of the observed variability of captures in reference to the studied climatic variables. Biplot graphs (Figs. 6-32, 6-33 and 6-34) are the vectors resulting from the participation degree of each of the studied variables in the components. It is noted in both cases, natural parks of “Tinença de Benifassà” and

“Font Roja”, that component 1 interacts directly and in equal proportion with captures growth and temperatures increasing. When temperatures increase, captures grow. But captures evolve inversely to rainfall, and they affect in a very small proportion. In the natural park of the “Lagunas de la Mata-Torrevieja” can be noted that the males captures are negatively affected by the increase of the maximum and minimum temperatures, which is associated to high temperatures (>35ºC) recorded since May. In addition, the scanty rains make the male captures to evolve in the same direction. It is noted that females have a different captures evolution than males being only slightly affected by the first component.

The second component relates negatively and to the same extent to male and female captures with the evolution of maximum and minimum temperatures. This component would explain the periods in which extreme temperatures make Agromyzidae populations to fall dramatically. This second component correlates male and female captures positively with precipitation in the “Font Roja” Natural Park, while in “Tinença de Benifassà” the correlation is negative and the proportion of affectation much smaller. Natural Park of the “Lagunas de La Mata-Torrevieja” follows a different behavior as occurs with the first component. There is a clear prevalence of females in dry periods and where maximum and minimum temperatures are less favorable for male presence. In the same sense, female presence in this park is less linked to temperatures changing, being host-plants presence the main reason that determines its presence (SPENCER, 1990).

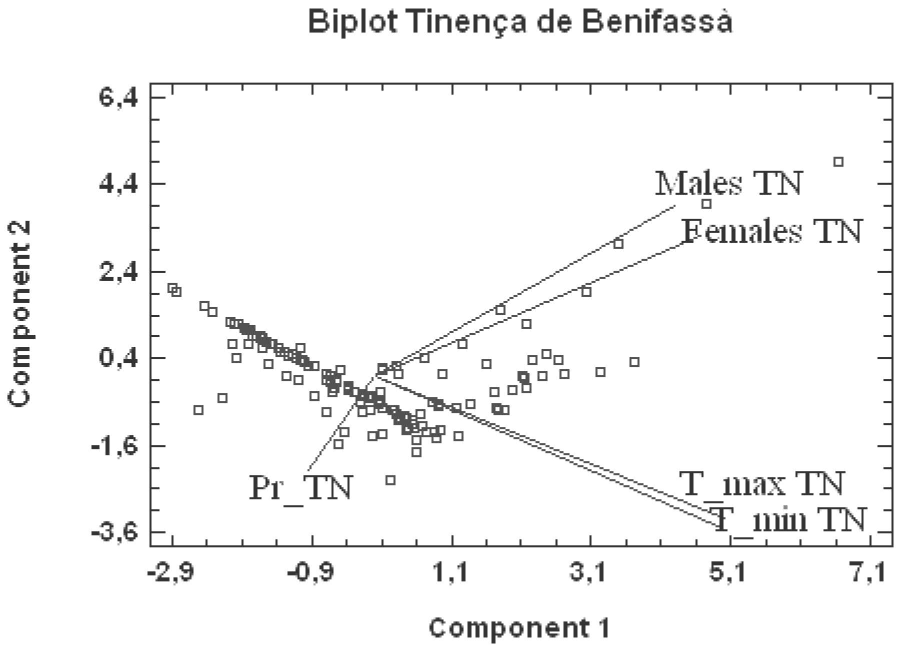

Figure 6-32. Biplot representation of components 1 and 2 in “Tinença de Benifassà”. Shows the result of the variables studied of captures, temperatures and precipitation.

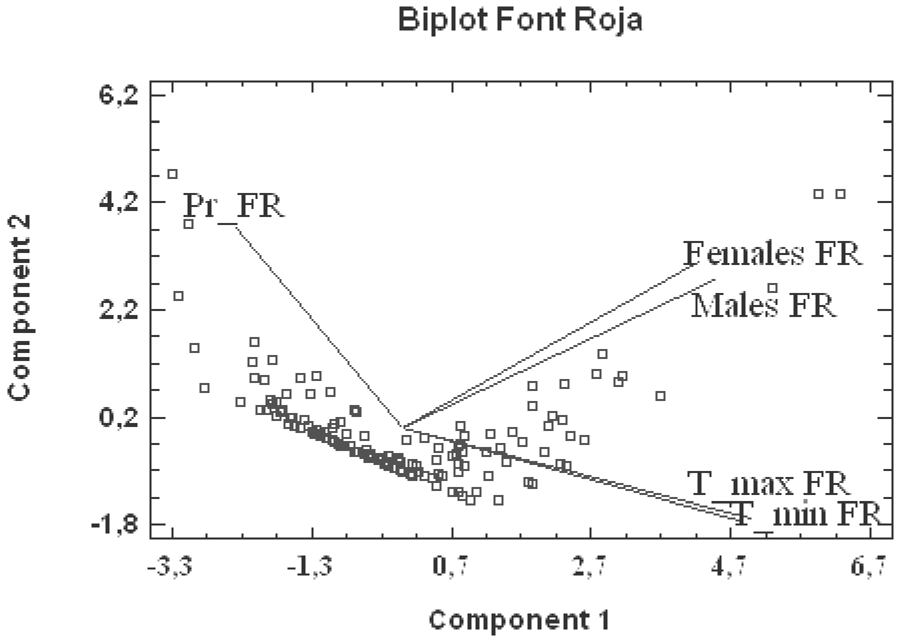

Figure 6-33. Biplot representation of the components 1 and 2 in "Font Roja". Shows the result of the variables studied of captures, temperatures and precipitation.

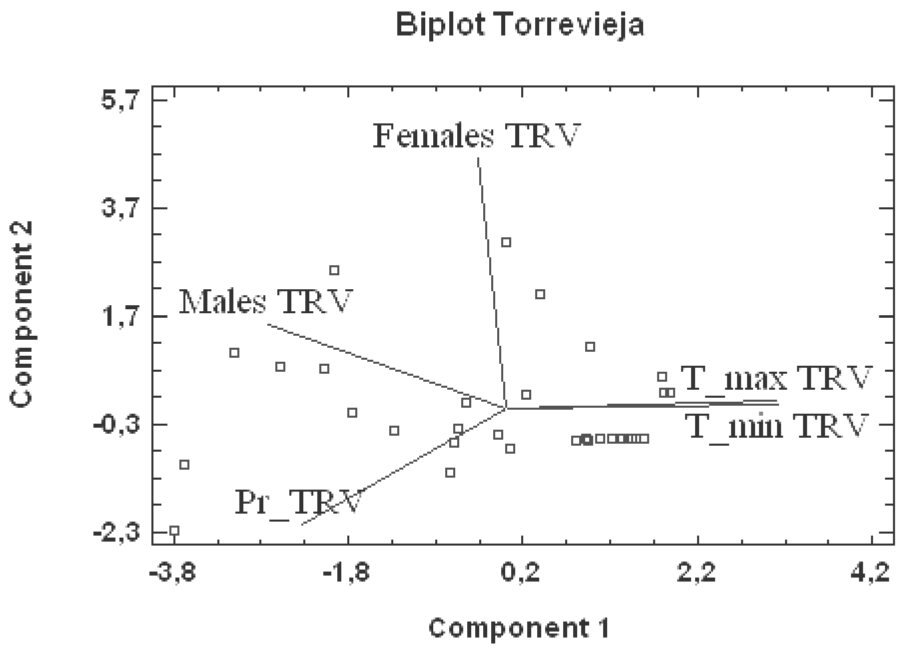

Figure 6-34. Biplot representation of the components 1 and 2 in "Lagunas de La Mata-Torrevieja". Shows the result of the variables studied of captures, temperatures and precipitation.

Analyzing every PCA variable separately through a Multiple Regression Analysis (MRA) taking captures as dependent variables and climate variables as independent their significance is studied. Based on results, these show the achieved multiple regression models and comprehensively studied for 3 years (Table 6-16).

Multiple Regression Analysis

	Captures TN		Captures FR		Captures TRV	
	Males	**Females**	**Males**	**Females**	**Males**	**Females**
T_max	****	****	****	****	***	NS
T_min	****	****	****	****	**	NS
T_med	****	****	****	****	**	NS
Pr	NS	NS	*	NS	NS	NS

* , **, ***,**** significant at the 0.1, 0.01, 0,05, and 0.001 probability levels, respectively. NS, non significant.

Table 6-16. Results of multiple regression analysis based on climatic variables of temperatures and precipitation for the 3 years studied. It is indicated the significant effects on captures of males and females.

Models resulting from MRA that correlate captures of males and females with climatic variables are as follows: Males TN = -1,363 + 0,171T_med TN r^2 = 10,044; Females TN = -0,508 + 0,063T_med TN r^2 = 16,736; Males FR = -2,722 + 0,206T_max FR r^2 = 27,009; Females FR = -0,854 + 0,066T_max FR r^2 = 20,420; Males TRV = 3,377 - 0,077T_max TRV r^2 = 4,002. The proposed models are with which can be better explained the evolution of captures of males and females in each of the studied parks. The low correlation indicates the difficulty of correlating the populations evolution with the temperatures in open environments. However, the used tools let us know the temperature influence degree in the seasonality of *Pseudonapomyza* genus.

Conclusions

Establishment of preventive models within the family *Agromyzidae* is more effective in case of carrying out the population control of crop pests. This owes to that the biotopes are simpler due to a restricted number of host plants, as well as to be able to control other variables such as humidity, photoperiod, the effect of pesticides, etc. (SATAKE *et al.*, 2006). So that, the study of climatic effects on Agromyzidae are primarily focused in greenhouses (OZAWA *et al.*, 2005, ZHOU *et al.*, 2003, TANAKA *et al.*, 2000). In nature, Agromyzidae populations suffer large fluctuations over years being primarily determined by the presence of host-plants (SPENCER, 1990).

Captures phenology and the temperature fluctuation in the natural parks of “Tinença de Benifassà”, “Font Roja”, and “Lagunas of la Mata-Torrevieja” are supported with a significant PCA analysis (Table 6-16). Population growth is proportional to the temperature increase except when the temperature reaches critical thresholds of maximum and minimum (Figs. 6-19, 6-20, and 6-21). Globally the largest *Pseudonapomyza* populations in “Tinença de Benifassà” are recorded in late May and early June captureing about 20 males/week. In natural park “Font Roja” the most numerous male populations can be fixed at around 17-19 males/week in June and July. The ignorance of much of the *Pseudonapomyza* species in Spain is evident, due to the existence of a minimum of 5 new species found by means of our research in the Community of Valencia.

Pseudonapomyza behavior in the natural park of “Lagunas de la Mata-Torrevieja” is different to that observed in the other two natural parks studied. The extremely high temperatures recorded in summer (>40ºC) means the vegetation since mid-May is practically limited to monocots and crass plants. It is noted that male fluctuation mainly depends on temperature, while the female seems to have populations less conditioned to this factor. Hosts-plants are the main requirement for the presence of female Agromyzidae populations necessary for food as well as to complete their life cycle (SPENCER, 1990).

The “Tinença de Benifassà” and “Font Roja” typically produce 4-5 generations from mid-spring to late summer with sex-ratio peaks of 10-12 males/females (Figs. 6-22, and 6-23). But in the “Lagunas de la Mata-Torrevieja” *Pseudonapomyza* populations are concentrated in spring and mid-autumn to early winter, avoiding the high temperatures (>40ºC) recorded during the day in summer, with 4-5 total generations and maximum sex-ratios of 8 males/females (Fig. 6-24). In the “Lagunas de la Mata-Torrevieja” there is a clear predominance of females compared with males especially in summer with populations that become so high (8 females/week) as males in the most favorable periods of spring.

Overall it appears that precipitations are not directly determining the *Pseudonapomyza* captures, though the rains conduce to the development and growth of vegetation, which are necessary for Agromyzidae populations to be present in a significant way. This is evident in the study. For example, 2004 was particularly dry in “Tinença de Benifassà” which meant there were practically no captures.

Development of predictive models in controlled environments permit the evaluation of trends in population growth, but are subject to uncontrollable factors such as the presence of host-plants, the presence of populations of hymenopteran parasitoids, sharp fluctuations of temperatures, winds, or the presence of the moisture needed for larval development. It is pointed out that synchrony among the larval hatching and bud burst of host-plants strongly affects to larval survival (KOMATSU & AKIMOTO, 1995). Currently the effects of global warming cause an increase in temperature that may enhance the overwintering factor and so to increase the number of generations per year (YAMAMURA & KIRITANI, 1998).

The importance of the obtained results are focused mainly in the knowledge of population phenology of *Pseudonapomyza* in the three natural parks studied. Captures are explained by the temperature effects with a significance degree of 79,87%. Understanding the periods in which *Pseudonapomyza* is present and the temperature thresholds in which its development is favored can help us to the establishment of pest control programs.

The study is open to further comparisons with other places in Community of Valencia, as well as other genera and families of Diptera Agromyzidae. In any case the main determinant factor of *Pseudonapomyza* fluctuations is the changes of temperatures to be intrinsically related to hosts-plants seasonality.

Acknowledgements

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Conclusions 7

1. As a result of the taxonomic study of Agromyzidae the faunal wealth has been characterized in the Natural Parks of "Tinença of Benifassà", "Font Roja" and "Lagunas de la Mata-Torrevieja" revealing a broad richness of fauna with a total of 61 species distributed in 16 genera that were already mentioned in the literature.

2. The list of Agromyzidae species of Spain is increased adding a total of 23 new references to Agromyzidae belonging to 8 genera: *Agromyza anthracina* Meigen, 1830; *A. bromi* Spencer, 1966; *A. hiemalis* Becker, 1908; *A. megalopsis* Hering, 1933; *Aulagromyza buhri* (de Meijere, 1938); *Au. luteoscutellata* (de Meijere, 1924); *Au. similis* (Brischke, 1880); *Au. trivitatta* (Loew, 1873); *Cerodontha (Poemyza) lapplandica* (Rydén, 1956); *Liriomyza amoena* (Meigen, 1830); *L. erucifolii* de Meijere, 1944; *L. graminivora* Hering, 1949; *L. samogitica* Pakalniškis,1996; *Melanagromyza eupatorii* Spencer, 1957; *M. nibletti* Spencer, 1957; *M. spinulosa* Spencer, 1974; *Ophiomyia labiatarum* Hering, 1937; *O. penicillata* Hendel, 1920; *Phytobia cerasiferae* (Kangas, 1955); *P. lunulata* (Hendel, 1920); *Phytomyza bupleuri* Hering, 1963; *Ph. tanaceti* Hendel, 1923 and *Pseudonapomyza palliditarsis* Cerny, 1992.

3. Five new species of *Pseudonapomyza* have been described in Spain (*Ps. curvata* n. sp., *Ps. benifassae* n. sp., *Ps. longitata* n. sp., *Ps. poaceae* n. sp. and *Ps. sicicornis* n. sp.), as well as the fact of the presence of another 21 new species of Agromyzidae for science distributed between the *Agromyza* (3), *Cerodontha (Poemyza)* (1), *Melanagromyza* (1), *Ophiomyia* (6), *Liriomyza* (4), *Metopomyza* (1) and *Phytomyza* (5) genera.

4. *Melanagromyza sojae* (Zehnter, 1900) an important stem-miner pest of leguminosae crops and *Pseudonapomyza atratula* Zlobin, 2002 a potentially harmful species of cereal crops are cited for the first time in Europe.

5. The current composition of Agromyzidae known in Spain (including the Balearic and Canary islands) reaches the figure of 296 species, being 88 of economic interest for the Agriculture.

6. The biodiversity study has shown that the Natural Park with the most faunal wealth is "Tinença de Benifassà" with 89 species. "Font Roja" and "Lagunas de La Mata-Torrevieja" present a similar number of species with 38 and 37 species, respectively, although their faunal composition is different. The major number of genera in "Tinença Benifassà" are *Liriomyza* (28.4%), *Ophiomyia* (13.7%) and *Pseudonapomyza* (10.6); in "Font Roja" are *Pseudonapomyza* (61.8%) and *Ophiomyia* (21%); while in the "Lagunas de La Mata-Torrevieja" it highlights *Agromyza* (30.8%), *Pseudonapomyza* (12.9%) and *Liriomyza* (10.7%).

7. The Log-Normal distribution has been the correct to explain the behaviour of captures in "Font Roja" since they are fairly homogeneous in monocots miners. While the Logarithmic Series model explains the trends of the captures in the Natural Parks of "Tinença of Benifassà" and "Font Roja" within Phytomyzinae.

8. In Tinença de Benifassà" highlights the strong dominance of certain species like *Ophiomyia beckeri*, *Agromyza bromi*, *Melanagromyza albocilia*, *Liriomyza brassicae* and *Liriomyza bryoniae*. The "Lagunas de La Mata-Torrevieja" shows a greater dominance of species than "Font Roja" by the presence of species such as *Pseudonapomyza atratula* and several species belonging to the genera *Agromyza* and *Liriomyza*. Finally, in Font Roja highlights the dominance of the genera *Ophiomyia* and *Pseudonapomyza*.

9. The study of mined plants has revealed the presence of 34 new host-plants for Agromyzidae of a total of 153 interactions established in 94 genera belonging to 27 botanical families. The interactions were established on 27 Agromyzidae species: *Ophiomyia beckeri* (Hendel, 1923); *Ophiomyia ononidis* Spencer, 1966; *Amauromyza (Amauromyza) balcanica* (Hendel, 1931); *Amauromyza (Amauromyza) carlinae* (Hering, 1944); *Amauromyza (Amauromyza) morionella* (Zetterstedt, 1848); *Amauromyza (Cephalomyza) flavifrons* (Meigen, 1830); *Amauromyza (Cephalomyza) karli* (Hendel, 1927); *Chromatomyia horticola* (Goureau, 1851); *Chromatomyia periclymeni* (Hendel, 1922); *Liriomyza brassicae* (Riley, 1884); *Liriomyza bryoniae* (Kaltenbach, 1858); *Liriomyza cicerina* (Rondani, 1875); *Liriomyza congesta* (Becker, 1903); *Liriomyza dianthicola* (Venturi, 1949); *Liriomyza orbona* (Meigen, 1830); *Liriomyza pascuum* (Meigen, 1838); *Liriomyza strigata* (Meigen, 1830); *Liriomyza trifolii* (Burgess *in* Comstock, 1880); *Napomyza lateralis* (Fallén, 1823); *Phytomyza hellebori* Kaltenbach, 1872; *Phytomyza plantaginis* Robineau-Desvoidy, 1851; *Pseudonapomyza atratula* Zlobin, 2002; and five undetermined species belonging to genera *Liriomyza*, *Phytomyza* and *Pseudonapomyza*.

10. Twenty-four new interactions included in 8 botanical families have been added to the catalogue of the host-plants of the world Agromyzidae (Diptera). New interactions belong to the following genera of plants: *Anagallis* L., *Chenopodium* L., *Catananche* L., *Centaurea* L., *Mantisalca* Cass, *Phagnalon* Cass., *Reichardia* Roth., *Serratula* L., *Urospermum* Scop., *Xeranthemum* L., *Diplotaxis* DC., *Lepidium* L., *Sysimbrium* L., *Blackstonia* Hudson., *Avena* L., *Hordeum* L., *Lotus* L., *Medicago* L. and *Silene* L.

11. Results of the multivariate analysis of climatic data, including genus of *Pseudonapomyza*, show that 82% of differences in captures are due to the *Pseudonapomyza* bioecology within each park, being essential the temperature, with which can be explained the 79% of the population dynamics in the studied areas. Overall, it seems that precipitations do not directly determine the *Pseudonapomyza* captures.

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Annexes 9

9.1 Annexe 1: List of Agromyzidae species of Spain$^{\Delta}$ and their synonyms

$^{\Delta}$**Including the Agromyzidae biodiversity of Balearic and Canary islands.**

Subfamily **Agromyzinae**

Agromyza Fallén, 1810
Domomyza: authors, nec Rondani, 1856.
Mesonevra Lioy, 1864.
Stomacrypolus Enderlein, 1936.
Stomacrypeolus: error or possibly Enderlein, 1936.

Agromyza abiens Zetterstedt, 1848
Agromyza albipennis Meigen, 1830
  albohyalinata Zetterstedt, 1848
  dubitata Malloch, 1913
  fennica Griffiths, 1963
Agromyza ambigua Fallén, 1823
  niveipennis Zetterstedt, 1848
  heteroptera (Loew, 1858)
Agromyza anthracina Meigen, 1830 *
  freyi Hendel, 1931
Agromyza apfelbecki Strobl, 1902
  apfelbecki Strobl, 1904 praeocc.
  andalusiaca Strobl, 1906
Agromyza baetica Griffiths, 1963
Agromyza bromi Spencer, 1966 *
Agromyza brunnicosa Becker, 1908 (only present in Canay Islands)
Agromyza cinerascens Macquart, 1835
Agromyza conjuncta Spencer, 1966
Agromyza demeijerei Hendel, 1920
Agromyza erodii Hering, 1927 (only present in Canary Islands)
Agromyza felleri Hering, 1941
  ? *rubiginosa* Griffiths, 1955
Agromyza frontella (Rondani, 1875)
Agromyza frontosa (Becker, 1908) (only present in Canary Islands)
Agromyza graminicola Hendel, 1931
Agromyza granadensis Spencer, 1972
***Agromyza hiemalis* Becker, 1908** *
Agromyza hierroensis Spencer, 1957 (only present in Balearic and Canary Islands)
Agromyza idaeiana Hardy 1853
  potentillae (Kaltenbach, 1864)
  spiraeae Kaltenbach, 1867

sanguisorbae Hendel, 1931
leucomaculata Vimmer, 1931
stackelbergi (Frey, 1946)
erici Rydén, 1952
Agromyza intermittens (Becker, 1907)
secalina (Hering, 1925)
Agromyza johannae de Meijere, 1924
Agromyza lathyri Hendel, 1923
Agromyza lucida Hendel, 1920
holosericea Strobl, 1893
airae Karl, 1926
Agromyza luteifrons Strobl, 1906
albipila (Becker, 1908)
Agromyza luteitarsis (Rondani, 1875)
articulata (Rondani, 1875)
Agromyza marionnae Griffiths, 1963
alandensis Spencer, 1976
***Agromyza megalopsis* Hering, 1933** *
Agromyza mobilis Meigen, 1830.
Agromyza myosotidis Kaltenbach, 1864
hirtella Becker, 1908
Agromyza nana Meigen, 1830
anthracipes (Rondani, 1875)
brevinervis (Rondani, 1875)
medicaginis Robineau-Desvoidy, 1851
trifolii Kaltenbach, 1872
Agromyza nigrescens Hendel, 1920
microchaeta Hendel, 1920
heringi de Meijere, 1925
nigrescens japonica Tsujita, 1951
oycoviensis Beiger, 1959
Agromyza nigripes Meigen, 1830
agrosticola Hering, 1927
viridominalis Spencer, 1957
nigripes brachypodii Griffiths, 1963
Agromyza nigrociliata Hendel, 1931
? *kinkaidi* Malloch, 1913
Agromyza obscuritarsis (Rondani, 1875)
Agromyza pseudoreptans Nowakowski, 1967 (only present in Canary Islands)
Agromyza pulla Meigen, 1830
genistae Hendel, 1931: 59
pyrrhocera (Hering, 1951)
Agromyza reptans Fallén, 1823 (only present in Canary Islands)
Agromyza rondensis Strobl, 1900
occellaris (Hendel, 1920)
ocellaris : Equest unjustified.
nigrifemur Hendel, 1931: 59
veris Hering, 1951
Agromyza rufipes Meigen, 1830
buhriella Hering, 1954

Agromyza spenceri Griffiths, 1963
Agromyza trebinjensis Strobl, 1900
celtidis Nowakowski, 1960
Agromyza varicornis Strobl**,** 1900
watersi Spencer, 1957
Agromyza vicifoliae Hering, 1932
***Agromyza* n. sp. 1**
***Agromyza* n. sp. 2**
***Agromyza* n. sp. 3**

Hexomyza Enderlein, 1936.

Hexomyza sarothamni (Hendel, 1923)
Hexomyza schineri (Giraud, 1861)
Hexomyza simplicoides (Hendel, 1920)
kirgizica (Rohdendorf-Holmanová, 1959)

Japanagromyza Sasakawa, 1958

Japanagromyza salicifolii (Collin, 1911)

Melanagromyza Hendel, 1920
Limnoagromyza Malloch, 1921

Melanagromyza aenea (Meigen, 1830)
fuscociliata Hendel, 1931
Melanagromyza aeneoventris (Fallén, 1823)
aeneiventris : error
cirsii (Rondani, 1875)
leucoptera (Czerny *in* Czerny and Strobl, 1909)
Melanagromyza albocilia Hendel, 1931
convolvuli Spencer, 1971
Melanagromyza angeliciphaga Spencer, 1969
Melanagromyza cunctans (Meigen, 1830)
Melanagromyza dettmeri Hering, 1933
Melanagromyza fabae Spencer**,** 1973
***Melanagromyza eupatorii* Spencer, 1957** *
Melanagromyza ferulae Spencer, 1966 *
Melanagromyza foeniculi Spencer, 1960
Melanagromyza lappae (Loew, 1850)
multiseta Rydén, 1949
nitens Rohdendorf-Holmanová, 1958
***Melanagromyza nibletti* Spencer, 1957** *
Melanagromyza siciliensis Spencer, 1966
***Melanagromyza sojae* Zehnter, 1900** *
***Melanagromyza spinulosa* Spencer, 1974** *
Melanagromyza tripolii Spencer, 1957
Melanagromyza verbasci Spencer, 1957
***Melanagromyza* n. sp. 1**

Ophiomyia Braschnikov, 1897
Braschnikov, 1897
Tylomyza Hendel, 1931
Stiropomyza Enderlein, 1936
Siphonomyza Enderlein, 1936
Aulomyza Enderlein**,** 1936
Siridomyza Enderlein**,** 1936
Solenomyza Enderlein, 1936
Stirops Enderlein, 1936
Triopisopa Enderlein, 1936
Carinagromyza Sasakawa 1954

Ophiomyia alliariae Hering, 1954
vitiosa Spencer, 1964
Ophiomyia asparagi Spencer, 1964
Ophiomyia beckeri (Hendel, 1923)
euphorbiae (Hendel, 1923)
goniaea (Hendel, 1931)
Ophiomyia cunctata (Hendel, 1920)
Ophiomyia curvipalpis (Zetterstedt, 1848)
major (Strobl, 1900)
major (Srobl, 1900)
proboscidea (Strobl, 1900)
prominens (Becker, 1908)
achilleae Hering, 1937
Ophiomyia eucodonus Hering, 1960
fennoniensis Spencer, 1976
Ophiomyia fennoniensis Spencer, 1976
Ophiomyia galii Hering, 1937
Ophiomyia heracleivora Spencer, 1957
Ophiomyia inaequabilis (Hendel, 1931) *
Ophiomyia labiatarum Hering, 1937 *
Ophiomyia major (Strobl, 1900)
Ophiomyia maura (Meigen, 1838)
asteris Kuroda, 1954
bicornis (Kaltenbach, 1869)
Ophiomyia melandricaulis Hering, 1943
moehringiae Hering, 1962
Ophiomyia nasuta (Melander, 1913) *
madizina Hendel, 1920
youngi (Malloch, 1914)
Ophiomyia ononidis Spencer**,** 1966
Ophiomyia orbiculata (Hendel, 1931) *
hexachaeta (Hendel, 1931)
nostradamus (Hering, 1933)
paracelsus (Hering, 1933)
cagliostro (Rohdendorf-Holmanová, 1958)
***Ophiomyia penicillata* Hendel, 1920** *
Ophiomyia pinguis (Fallén, 1820)
Ophiomyia pulicaria (Meigen, 1830)

olgae (Hering, 1922):
Ophiomyia rostrata (Hendel, 1920)
Ophiomyia submaura Hering, 1926
aragonensis Hering, 1943
Ophiomyia vimmeri Zlobin, 1994 *
Ophiomyia vitiosa Spencer, 1964
***Ophiomyia* n. sp. 1**
***Ophiomyia* n. sp. 2**
***Ophiomyia* n. sp. 3**
***Ophiomyia* n. sp. 4**
***Ophiomyia* n. sp. 5**
***Ophiomyia* n. sp. 6**

Subfamily **Phytomyzinae**

Selachopinae Tullgren & Wahlgren, 1922
Encoelocerinae Hackman & Väisanen, 1985: Emendation
Eucolocerinae: error, sieche Emendation

Amauromyza Hendel, 1931
Catalpomyza Spencer, 1977 (Subgenus)
Annimyzella Spencer, 1981 (Subgenus)
Catalpomyza Spencer, 1977 (Subgenus)
Annimyzella Spencer, 1981 (Subgenus)

Subgenus ***Amauromyza*** Hendel, 1931

Redia Lioy, 1864 praeocc. (nec Filippi)
Melanophytobia Hering, 1960
Irenomyia Nowakowski, 1960

A. (Amauromyza) balcanica (Hendel, 1931)
A. (Amauromyza) carlinae (Hering, 1944)
A. (Amauromyza) morionella (Zetterstedt,1848)
novakii (Strobl, 1902)
novakii (Strobl, 1904) praeocc.
novaki : error.

Subgenus ***Cephalomyza*** Hendel, 1931
Trilobomyza Hendel, 1931
Campanulomyza Nowakowski, 1962

A. (Cephalomyza) flavifrons (Meigen, 1830)
exigua (Meigen, 1830)
xanthocephala (Zetterstedt, 1860)
A. (Cephalomyza) gyrans (Fallén, 1823)
A. (Cephalomyza) karli (Hendel, 1927) *
A. (Cephalomyza) luteiceps (Hendel, 1920) *
hendeli (de Meijere, 1924)
A. (Cephalomyza) madrilena (Spencer, 1957)

A. (Cephalomyza) monfalconensis (Strobl, 1909)
A. (Cephalomyza) obscuripennis (Strobl, 1906)
strobli (Hendel, 1920)
A. (Cephalomyza) verbasci (Bouché, 1847)
*macquarti (*Goureau, 1851)

Aulagromyza Enderlein, 1936

Phytagromyza: auct., nec Hendel, 1920
Paraphytomyza Enderlein, 1936
Rubiomyza Nowakowski, 1962

Aulagromyza anteposita (Strobl, 1898) (only present in Balearic and Canary Islands)
Aulagromyza buhri **(de Meijere, 1938)** *
Aulagromyza cornigera (Griffiths, 1973)
Phytagromyza lonicerae auct., nec Robineau-Desvoidy, 1851
Aulagromyza discrepans (van der Wulp, 1871)
Aulagromyza hendeliana (Hering, 1926)
hendeliana (de Meijere, 1926)
harlemensis: (Hendel, 1920)
Aulagromyza iberica (Spencer, 1960)
Aulagromyza lucens (de Meijere, 1924) (only present in Balearic Islands)
Aulagromyza luteoscutellata (de Meijere, 1924) *
lonicerae (Brischke, 1880)
falleni (Rydén, 1952)
lonicerarum (Frey, 1946)
xylostei auct., nec Robineau-Desvoidy, 1851
Aulagromyza morenae (Strobl, 1900)
Aulagromyza orphana (Hendel, 1920)
Aulagromyza populi (Kaltenbach, 1864)
populivora (Hendel, 1926)
Aulagromyza similis (Brischke, 1880) *
praecedens (Strobl, 1898)
centaureana (Hering, 1925)
Aulagromyza trivittata (Loew, 1873) *
tristriata (Hendel, 1932)

Calycomyza Hendel, 1931

Calycomyza artemisiae (Kaltenbach, 1856)
atripes (Zetterstedt, 1860)
atripes (Brischke, 1880)
artemisiae (Kaltenbach, 1873) praeocc.
artemisiae marcida Spencer, 1969
Calycomyza flavomaculata (Spencer, 1960)
Calycomyza humeralis (von Roser, 1840)
artemisiae (Kaltenbach, 1873) praeocc.
bellidis (Kaltenbach, 1873)
atripes (Brischke, 1880)

Cerodontha Rondani, 1861
Cerodonta Hendel, 1910

Subgenus ***Cerodontha*** Rondani, 1861
Odontocera Macquart, 1835
Ceratomyza Schiner, 1862
Micromma Philippi, 1865

C. (Cerodontha) denticornis (Panzer, 1806)
meigenii.(Fallén, 1823)
nigritarsis (Meigen, 1830)
acuticornis (Meigen, 1830)
confinis (Meigen, 1830)
tarsella (Zetterstedt, 1848)
nigriventris (Strobl, 1900)
nigroscutellata (Strobl, 1900)
semivittata (Strobl, 1909)
lacustris Garg, 1971
narkandae Singh & Ipe, 1973
C. (Cerodontha) flavicornis (Egger, 1862)
C. (Cerodontha) fulvipes (Meigen, 1830)
spinicornis (Macquart, 1835)
femoralis (Meigen, 1838)
occulta (Meigen, 1838)
C. (Cerodontha) hennigi Novakowski, 1967
lateralis (Zetterstedt, 1848)
C. (Cerodontha) phragmitophila Hering, 1935
arundinis Nowakowski, 1973
C. (Cerodontha) vandalitiensis Spencer, 1966

Subgenus ***Dizygomyza*** Hendel, 1920

C. (Dizigomyza) bimaculata (Meigen, 1830)
basilaris (Meigen, 1838)
laterella (Zetterstedt, 1838)
flavocincta (Strobl, 1880)
C. (Dizigomyza) crassiseta (Strobl, 1900)
poae (Hendel, 1931)
C. (Dizigomyza) fasciata (Strobl, 1880) *
plumbea (Hendel, 1931)
grisea (Rydén, 1952)
C. (Dizigomyza) iraeos (Robineau-Desvoidy, 1851)
iraeos (Robineau-Desvoidy, 1851)
ireos (Goureau, 1851)
ireos (Goureau, 1851): error.
ircos: printing error of authors including Goureau, 1851.
C. (Dizigomyza) luctuosa (Meigen, 1830)
effusi (Karl, 1926)
C. (Dizigomyza) morosa (Meigen, 1830)
grossicornis (Zetterstedt, 1860)

soenderupi Frey, 1950 (misidentification)
islandica Griffiths, 1968
graminiphila Garg, 1971

Subgenus ***Icteromyza*** Hendel, 1931

C. (Icteromyza) capitata (Zetterstedt, 1848)
fronticornis (Rondani, 1875)
genualis (Melander, 1913)
coloradensis (Malloch, 1913)
C. (Icteromyza) geniculata (Fallén, 1823)
flavogeniculata (von Roser, 1840)
lunzensis (Hering *in* Lindner, 1943)
C. (Icteromyza) lineella (Zetterstedt, 1838)
hirticeps (Hendel, 1920)
C. (Icteromyza) piliseta (Becker, 1903) (doubtful present)

Subgenus ***Poemyza*** Hendel, 1931

C. (Poemyza) atra (Meigen, 1830)
infinita (Becker, 1910)
C. (Poemyza) imbuta (Meigen, 1838)
deschampsiae (Spencer, 1957)
C. (Poemyza) incisa (Meigen, 1830)
graminis (Kaltenbach, 1858: 142)
carbonella (Zetterstedt, 1860)
graminis (Kaltenbach, 1873
okazakii (Matsumura, 1916)
hammi Spencer 1971
C. (Poemyza) lateralis (Macquart, 1835)
vittigera (Zetterstedt, 1848)
variceps (Zetterstedt, 1860)
laminata (Brischke, 1880)
C. (Poemyza) lyneborgi Spencer,1972
C. (Poemyza) muscina (Meigen, 1830)
***C. (Poemyza) lapplandica* (Rydén, 1956)** *
C. (Poemyza) pygmaea (Meigen, 1830)
verrucosa (Hendel, 1931)
C. (Poemyza) pygmella (Hendel, 1931) (only present in Canary Islands)
C. (Poemyza) pygmina (Hendel, 1931)
C. (Poemyza) superciliosa (Zetterstedt, 1860)
coquilletti (Malloch, 1913)
lateralis: authors.
***C. (Poemyza)* n. sp. 1**

Subgenus ***Xenophytomyza*** Frey, 1946

C. (Xenophytomyza) atronitens (Hendel, 1920) *
C. (Xenophytomyza) biseta (Hendel, 1920)
uniformis (Hering, 1926)

crassinervis (Frey, 1946)

Chromatomyia Hardy, 1849

Chromatomyia aprilina (Goureau, 1851)
xylostei (Robineau-Desvoidy, 1851)
lonicerae (Kaltenbach, 1862)
lonicerella (Hendel, 1932)
Chromatomyia aragonensis (Griffiths, 1967)
Chromatomyia ciliata (Hendel, 1935)
Chromatomyia gentianae (Hendel, 1920)
veratri (Hering, 1941)
hecate Pakalniskis, 1998
Chromatomyia horticola (Goureau, 1851)
atricornis (Meigen, 1830) pro parte, nomen dubium.
cucumidis (Macquart, 1854)
tropaeoli (Dufour, 1857)
fediae (Kaltenbach, 1860)
linariae (Kaltenbach, 1862)
pisi (Kaltenbach, 1864)
meliloti (Brischke, 1882)
subaffinis (Malloch, 1914)
lactucae (Vimmer, 1928)
bidensivora (Séguy, 1951)
nainiensis (Garg, 1971)
Chromatomyia lindbergi (Spencer, 1957)
Chromatomyia milii (Kaltenbach, 1864)
jacobaeae (de Meijere, 1924)
intermedia (Spencer, 1957)
Chromatomyia paraciliata Godfray, 1985
Chromatomyia periclymeni (Hendel, 1922)
periclymeni (de Meijere, 1924)
Chromatomyia primulae (Robineau-Desvoidy, 1851)
primulae (Goureau, 1851)
Chromatomyia ramosa (Hendel, 1923)
olgae (Hering, 1925)
nigriventris (Hendel, 1935)
Chromatomyia scabiosae (Hendel, 1935)
Chromatomyia scabiosarum (de Meijere, 1934)
scabiosarum (Hering, 1936) praeocc.
Chromatomyia scolopendri (Robineau-Desvoidy, 1851)
scolopendri (Goureau, 1851)
scolopendrii (Goureau, 1851): Error
elegans (Goureau,.l851)
nevadensis (Strobl, 1900)
Chromatomyia succisae (Hering, 1922) *
Chromatomyia syngenesiae Hardy, 1849
atricornis (Meigen, 1830) pro parte, nomen dubium.
chrysanthemi (Kowarz, 1891) (in Lintner)

Gymnophytomyza Hendel, 1936

Gymnophytomyza heteroneura (Hendel, 1920)
  nigrivenis (Spencer, 1959)

Liriomyza Mik, 1894

Agrophila Lioy, 1864
Antineura Melander, 1913: praeocc.
Haplomyza Hendel, 1914
Praspedomyza Hendel, 1931
Craspedomyza Enderlein, 1936 a: 181, error for *Praspedomyza*.
Triticomyza Blanchard, 1938:

Liriomyza aculeolata Zlobin, 2002 *
***Liriomyza amoena* (Meigen, 1830)** *
Liriomyza andryalae Hering, 1927 (only present in Canary Islands)
Liriomyza asphodeli Spencer, 1957
Liriomyza asteris Hering, 1928
Liriomyza brassicae (Riley, 1884)
  cruciferarum Hering, 1927
  mitis (Curran, 1931)
  hawaiiensis Frick, 1952
  bulnesiae Spencer, 1963
  ornephila Garg, 1971
Liriomyza bryoniae (Kaltenbach, 1858)
  solani Hering, 1927
  hydrocotylae Hering, 1930
  mercurialis Hering, 1932
  triton Frey, 1945
  citrulli Rohdendorf, 1950
  nipponallia Sasakawa,1961
Liriomyza centaureae Hering, 1927
Liriomyza cepae (Hering, 1927)
Liriomyza cicerina (Rondani, 1875)
  ciceri (Navarro, 1903)
  ononidis de Meijere, 1925
  trichophthalma Hendel, 1931
Liriomyza congesta (Becker, 1903)
  leguminosarum de Meijere, 1924
  minima Hendel, 1931
  parva Hendel, 1931
  centaureana Hering, 1936
  nigripleura Rydén, 1956
  taraia Garg, 1971
  trifolii : authors (nec Burgess, 1880)
Liriomyza dianthicola (Venturi, 1949)
  jannonei (Séguy, 1950)
Liriomyza endiviae Hering, 1955
***Liriomyza erucifolii* de Meijere, 1944** *

Liriomyza eupatoriana Spencer, 1954
Liriomyza eupatorii (Kaltenbach, 1873)
orbitella Hendel, 1931
Liriomyza euphorbiana Hendel, 1931
Liriomyza europaea Zlobin, 2002 *
Liriomyza flaveola (Fallén, 1823)
blanda (Meigen, 1830)
albicornis (Meigen, 1838)
variegata (Meigen, 1838)
***Liriomyza graminivora* Hering, 1949** *
Liriomyza huidobrensis (Blanchard, 1926)
cucumifoliae Blanchard, 1938
langei Frick, 1951
decora Blanchard; 1954
dianthi Frick, 1958
Liriomyza infuscata Hering, 1926
portentosa Spencer, 1971
Liriomyza intonsa Spencer, 1976
Liriomyza kleiniae Hering, 1927 (only present in Canary Islands)
Liriomyza latigenis (Hendel, 1920)
Liriomyza lutea (Meigen, 1830)
fulvella (Rondani, 1875)
melanorhabda Hendel, 1931
Liriomyza myrsinitae Hering, 1957
Liriomyza nigrifrons Hendel, 1920 (only present in Canary Islands)
Liriomyza orbona (Meigen, 1830)
fuscolimbata (Strobl, 1900)
orbonella Hendel, 1931
Liriomyza pascuum (Meigen, 1838)
Liriomyza pedestris Hendel, 1931 *
Liriomyza phryne Hendel, 1931
Liriomyza polygalae Hering, 1927 *
Liriomyza pseudopygmina (Hering, 1933)
sisymbricaulis (Hering, 1962)
Liriomyza puella (Meigen, 1830)
mycelis Beiger, 1959
Liriomyza pusilla (Meigen, 1830)
fasciola (Meigen, 1838)
bellidis de Meijere, 1925
Liriomyza richteri Hering, 1927
***Liriomyza samogitica* Pakalniškis, 1996** *
Liriomyza scorzonerae Rydén, 1951
Liriomyza solivaga Spencer, 1971
Liriomyza sonchi Hendel, 1931
Liriomyza strigata (Meigen, 1830)
pumila (Meigen, 1830)
violae (Curtis, 1844)
Liriomyza tanaceti de Meijere, 1924
Liriomyza taraxaci Hering, 1927
aposeridis Beiger, 1972

Liriomyza tibidabensis Spencer, 1966
Liriomyza trifolii (Burgess *in* Comstock, 1880)
phaseolunulata Frost, 1943
alliovora Frick, 1955
Liriomyza umbilici Hering, 1927 (only present in Canary Islands)
Liriomyza xanthocera (Czerny *in* Czerny and Strobl, 1909)
infumata (Czerny *in* Czerny and Strobl, 1909)
crucifericola (Hering, 1951)
cisti (Spencer, 1960)
***Liriomyza* n. sp. 1**
***Liriomyza* n. sp. 2**
***Liriomyza* n. sp. 3**
***Liriomyza* n. sp. 4**

Metopomyza Enderlein, 1936

Metopomyza flavonotata (Haliday, 1833)
flavoscutellaris (Zetterstedt, 1838)
Metopomyza scutellata (Fallén, 1823) *
Metopomyza xanthaspis (Loew, 1858)
***Metopomyza* n. sp. 1**

Napomyza Westwood, 1840

Napomyza Curtis, 1837
Dinevra Lioy, 1864
Dineura Lioy, 1864: error.

Napomyza carotae Spencer, 1966
Napomyza cichorii Spencer, 1966
Napomyza hirticornis (Hendel, 1932)
Napomyza lateralis (Fallén, 1823)
Napomyza scrophulariae Spencer, 1966
hermonensis Spencer, 1974
Napomyza tripolii Spencer, 1966

Nemorimyza Frey, 1946

Nemorimyza posticata (Meigen, 1830)
virgaureae (Kaltenbach, 1869)
terminalis (Coquillett, 1895)
taeniola (Coquillett, 1904)
argenteolunulata (Strobl, 1909)

Phytobia Lioy, 1864

Dendromyza Hendel, 1931
Liomyzina Enderlein, 1936
Liomycina Enderlein, 1936
Shizukoa Sasakawa, 1963

Phytobia carbonaria (Zetterstedt, 1848)
nigra (Zetterstedt, 1838)
atra (Zetterstedt, 1838): error siehe *nigra*
latigenis (Hendel 1931)
Phytobia cerasiferae (Kangas 1955) *
Phytobia errans (Meigen, 1830)
Phytobia lunulata (Hendel 1920) *
laticeps (Hendel, 1931)

Phytoliriomyza Hendel, 1931
Xyraeomia Frick, 1952
Lemurimyza Spencer, 1965
Pteridomyza Nowakowski, 1962
Nesomyza Spencer, 1973:

Phytoliriomyza arctica (Lundbeck, 1901)
immaculata (Coquillett, 1902)
halterata (Becker, 1908)
formosensis (Mallch, 1914)
montana Frick, 1953
Phytoliriomyza dorsata (Siebke, 1863) *
bornholmensis Spencer, 1976
reverberata (Malloch, 1924)
striata (Hendel, 1931)
Phytoliriomyza immoderata Spencer, 1963 *
Phytoliriomyza oasis (Becker, 1907)
Phytoliriomyza pectoralis (Becker, 1908) (only present in Canary Islands)
Phytoliriomyza perpusilla (Meigen, 1830)
perpusilla "form *flaviventris*" (Strobl, 1910)
Phytoliriomyza scotica (Spencer, 1962) (only present in Canary Islands)
Phytoliriomyza variegata (Meigen, 1830)
astragali Brischke, 1880

Phytomyza Fallén, 1810
Phythomyza: error.

Phytomyza affinis Fallén, 1823
Phytomyza albiceps Meigen, 1830
flavoantennata Strobl, 1898
rydeniana Hering, 1949
Phytomyza albipennis Fallén, 1823
Phytomyza antennata Spencer, 1960
Phytomyza aronici Nowakowski, 1962
Phytomyza bellidina Hendel, 1934
Phytomyza biseta Hering, 1954
biseta Groschke, 1957
***Phytomyza bupleuri* Hering, 1963** *
Phytomyza burchardi Hering, 1927 (only present in Canary Islands)
Phytomyza cinerea Hendel, 1920
Phytomyza cirrhosae Spencer, 1969

Phytomyza cirsii Hendel, 1923
cirsicola Hendel, 1927
Phytomyza clematicaulis Hering, 1958
Phytomyza clematidis Kaltenbach, 1859
mallorcensis Spencer, 1969
? *improvisa* Spencer, 1976
Phytomyza continua Hendel, 1920
cardui Hering, 1943
zetterstedti Rydén,. 1951
zetterstedtiana Rydén, 1953
Phytomyza conyzae Hendel, 1920
centaureae Hering, 1924
arnicophila Hering, 1931
rivierae Hering,1932
inulina Hering, 1932
Phytomyza cortusifolii Spencer, 1965 (only present in Canary Islands)
Phytomyza crassiseta Zettersted, 1860
veronicae Kaltenbach, 1873
veronicae Brischke, 1880
Phytomyza doronici Hendel, 1923
doronici Hering, 1924: Praeocc.
Phytomyza evanescens Hendel, 1920
parallela Hendel, 1935
Phytomyza ferulae Hering, 1927
umbelliferarum Hering, 1935
dauci Spencer, 1957
Phytomyza ferulivora Griffiths,1956
Phytomyza flavicornis Fallén, 1823
luteiceps Sehgal, 1971
Phytomyza gymnostoma Loew, 1858
algeciracensis Strobl, 1906
phytomyzina (Hering, 1933)
palpata Hendel, 1935
palpalis Hendel, 1936
Phytomyza hellebori Kaltenbach, 1872 *
hellebori buhri Hering, 1930
helleborina Hering, 1932
Phytomyza meridionalis Spencer, 1972
Phytomyza minuscula Goureau, 1851
ancholiae Goureau, 1851
aquilegiae Robineau-Desvoidy, 1851
Phytomyza nigrita Spencer, 1960
Phytomyza nigritella Zetterstedt, 1848
Phytomyza obscura Hendel, 1920
Phytomyza obscurata Hendel, 1920
Phytomyza obscurella Fallén, 1823
Phytomyza origani Hering, 1931
Phytomyza orobanchia Kaltenbach, 1864
simillima Strobl, 1893
longicornis Czerny *in* Czerny and Strobl, 1909

Phytomyza petoei Hering, 1924 *
Petöi: incorrect spellings.
Phytomyza phillyreae Hering in Buhr, 1930
unedo Séguy, 1953
Phytomyza plantaginis Robineau-Desvoidy, 1851
plantaginis Goureau, 1851
robinaldi Goureau, 1851
genualis Loew, 1869.
nannodes Hendel, 1935
biseriata Hering, 1937
plantaginicaulis Hering, 1944
Phytomyza pullula Zetterstedt, 1848
matricariae Hendel, 1920:
anthemidis Hering, 1928
gotlandica (Rydén, 1952)
Phytomyza pulsatillae Hering, 1924
Phytomyza ranunculi (Schrank, 1803)
flaveola Fallén, 1810
flava Fallén, 1823
flavoscutellata Fallén, 1823
scutellata.Meigen, 1830
praecox Meigen, 1830
albipes Meigen, 1830
vitripennis Meigen, 1830
terminalis Meigen, 1830
pallida Meigen, 1830
maculipes Brullé, 1832
incisa Macquart, 1835
citrina von Roser, 1840
maculipes Zetterstedt, 1848
cinereovittata Zetterstedt, 1848
ranunculi Robineau-Desvoidy, 1851
zetterstedtii Schiner, 1864
ranunculi Kaltenbach, 1867
flavotibialis Strobl, 1902
flavotibialis Strobl, 1904
islandica Rydén, 1953
ranunculi pentalinearis Kuroda, 1954
tenuipennis Singh & Ipe, 1973.
Phytomyza rufipes Meigen, 1830
sulphuripes Meigen, 1830
sulfuripes: incorrect subsequent, spelling.
ruficornis Zetterstedt, 1848
femoralis Brischke, 1871
zetterstedtii genislatissimus Strobl, 1893
bistrigata Strobl, 1906
Phytomyza scotina Hendel, 1920
Phytomyza sedi Kaltenbach, 1869
catalaunica Spencer, 1960
Phytomyza solidaginis Hendel, 1920

hendeli Bryk, 1929
Phytomyza spinaciae Hendel, 1935
Phytomyza spoliata Strobl, 1906
Phytomyza spondylii Robineau-Desvoidy, 1851
sphondylii Goureau, 1851
spondylii Goureau, 1851
spondylii heracleiphaga Spencer, 1969
Phytomyza tanaceti Hendel, 1923 *
klimeschi Hering, 1943
Phytomyza tenella Meigen, 1830
zonata Zetterstedt, 1848
flavicoxa Strobl, 1900
pedicularis Hering, 1949
Phytomyza tetrasticha Hendel, 1927
? *hedickei* Hering, 1927
Phytomyza vitalbae Kaltenbach, 1872
***Phytomyza* n. sp. 1**
***Phytomyza* n. sp. 2**
***Phytomyza* n. sp. 3**
***Phytomyza* n. sp. 4**
***Phytomyza* n. sp. 5**

Pseudonapomyza Hendel, 1920

Pseudonapomyza atra (Meigen, 1830)
morio (Zetterstedt, 1848)
acuticornis (Loew, 1858)
nitidula (Malloch, 1913)
stanionyteae Pakalniskis, 1992.
Pseudonapomyza atratula Zlobin, 2002 *
***Pseudonapomyza curvata* n. sp. +**
***Pseudonapomyza benifassae* n. sp. +**
Pseudonapomyza europaea Spencer, 1973 *
***Pseudonapomyza longitata* n. sp. +**
Pseudonapomyza hispanica Spencer, 1973
Pseudonapomyza insularis Zlobin, 1993 (only present in Canary Islands)
Pseudonapomyza lacteipennis (Malloch, 1913)
***Pseudonapomyza palliditarsis* Cerny, 1992** *
***Pseudonapomyza mediterranea* n. sp. +**
***Pseudonapomyza sicicornis* n. sp. +**
Pseudonapomyza spicata (Malloch, 1914)
Pseudonapomyza spinosa Spencer, 1973
Pseudonapomyza strobliana Spencer, 1973
Pseudonapomyza vota Spencer, 1973
***Pseudonapomyza* sp. 1**
***Pseudonapomyza* sp. 2**
***Pseudonapomyza* sp. 3**
***Pseudonapomyza* sp. 4**

Ptochomyza Hering, 1942

Ptochomyza asparagi Hering, 1942
Ptochomyza asparagivora Spencer, 1964

Xeniomyza de Meijere, 1934

Xeniomyza ilicitensis de Meijere, 1934

*** New reports for Spain**
+ New species for science

Note: New signaled species (+) and reports (*) include all species known starting from MARTINEZ (2004).

9.2 Annexe 2: Photographs of the most common leaf-miners in the Natural Parks studied

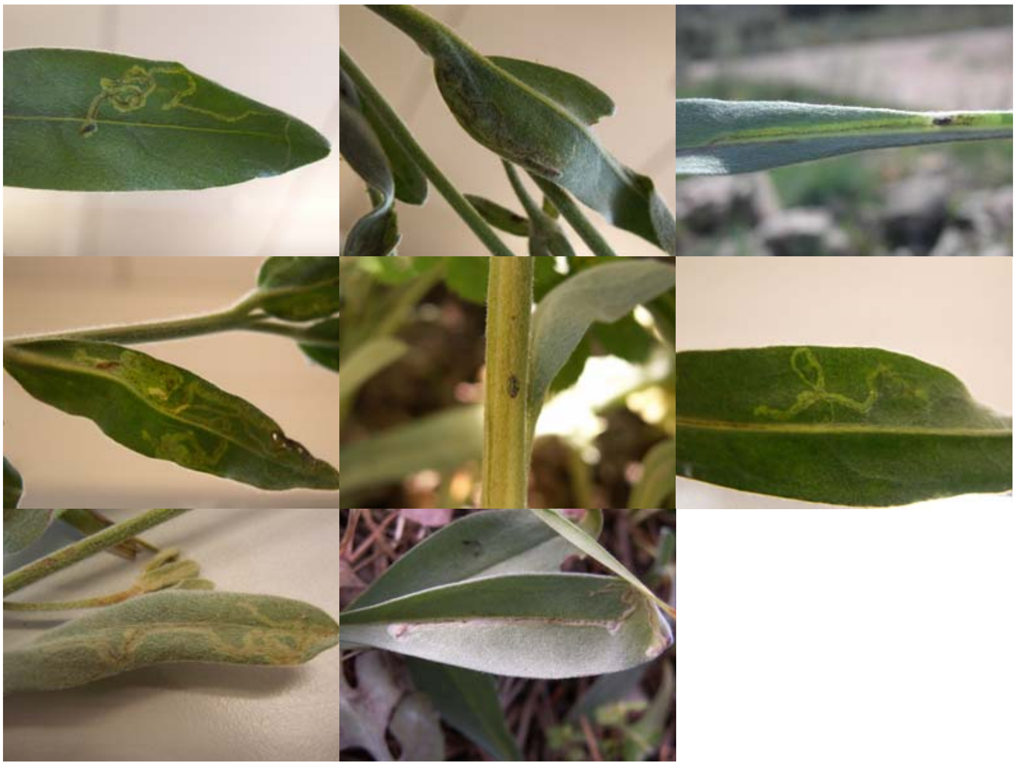
Boraginaceae

Cynoglossum creticum Mill.

Miner not identified

Cynoglossum cheirifolium L.

Chromatomyia horticola (Goureau, 1851)



Echium vulgare L.

Chromatomyia horticola (Goureau, 1851)



Heliotropium europaeum L.

Miner not identified

Lithospermum arvense L.

Chromatomyia horticola (Goureau, 1851)




Nonea vesicaria (L.) Rchb.

Miner not identified

Caprifoliaceae

Lonicera etrusca G. Santi

Chromatomyia periclymeni (Hendel, 1922)

Lonicera implexa Aiton

Miner not identified

Caryophyllaceae

Saponaria ocymoides L.

Miner not identified

Silene conica L.

Amauromyza (Cephalomyza) flavifrons (Meigen, 1830)

Silene conoidea L.

Amauromyza (Cephalomyza) flavifrons (Meigen, 1830)
Chromatomyia horticola (Goureau, 1851)

Silene dioica (L.) Clairv.

Miner not identified

Silene vulgaris (Moench) Garcke

Liriomyza brassicae (Riley, 1884)

Compositae

Asteriscus maritimus (L.) Less

Miner not identified

Calendula arvensis L.

Miner not identified

Carduncellus monspeliensium All.

Chromatomyia horticola (Goureau, 1851)

Carduus pycnocephallus L.

Chromatomyia horticola (Goureau, 1851)

Carthamus lanatus L.

Miner not identified

Catananche caerulea L.

Amauromyza (Cephalomyza) flavifrons (Meigen, 1830)
No image

Chromatomyia horticola (Goureau, 1851)

Centaurea aspera L. subsp. *stenophylla* (Dufour) Nyman

Chromatomyia horticola (Goureau, 1851)

Centaurea mariolensis Rouy

Chromatomyia horticola (Goureau, 1851)

Centaurea melitensis L.

Miner not identified

Centaurea rouyi Coincy

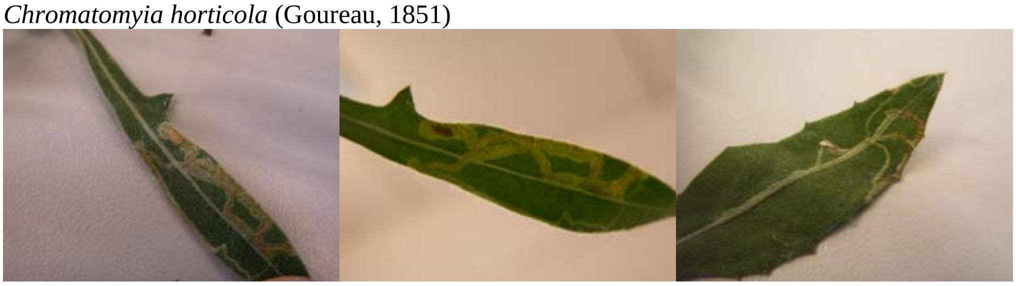
Ophiomyia beckeri (Hendel, 1923)

Centaurea scabiosa L. subsp. *cephalariifolia* (Willk.) Rivas Goday & Borja

Chromatomyia horticola (Goureau, 1851)
No image

Centaurea seridis L.

Chromatomyia horticola (Goureau, 1851)



Centaurea solstitialis L. subsp. *solstitialis*

Miner not identified

Centaurea spachii Schultz Bip. Ex Willk.

Miner not identified

Centaurea triumfettii All subsp. *semidecurrens* (jord.) O. Bolòs & Vigo

Chromatomyia horticola (Goureau, 1851)

Chrysantemum coronarium L.

Chromatomyia horticola (Goureau, 1851)

Cirsium arvense (L.) Scoop.

Miner not identified

Cirsium vulgare (Savi) Ten.

Amauromyza (Amauromyza) carlinae (Hering, 1944)

Crepis albida Vill.

Miner not identified

Crepis bursifolia L.

Ophiomyia beckeri (Hendel, 1923)

Crepis vesicaria L.

Chromatomyia horticola (Goureau, 1851)

Ophiomyia beckeri (Hendel, 1923)

Dittrichia viscosa (L.) Greuter

Miner not identified

Inula crithmoides L.

Miner not identified

Leontodon taraxacoides (Vill.) Mérat

Miner not identified

Leucanthemum gracilicaule (Dufour) Pau

Chromatomyia horticola (Goureau, 1851)

Leuzea conifera (L.) DC.

Miner not identified

Mantisalca salmantica (L.) Briq.& Cavill.

Chromatomyia horticola (Goureau, 1851)

Matricaria chamomilla L.

Miner not identified

Phagnalon saxalite (L.) Cass

Chromatomyia horticola (Goureau, 1851)

Reichardia intermedia (Schulz Bip.) Cout.

Miner not identified

Reichardia picroides (L.) Roth

Ophiomyia beckeri (Hendel, 1923)

Reichardia tingitana (L.) Roth

Miner not identified

Scabiosa atropurpurea L.

Chromatomyia horticola (Goureau, 1851)

Scorzonera laciniata L.

Miner not identified

Senecio auricula Bourg. Ex. Coss.

Miner not identified

Senecio vulgaris L.

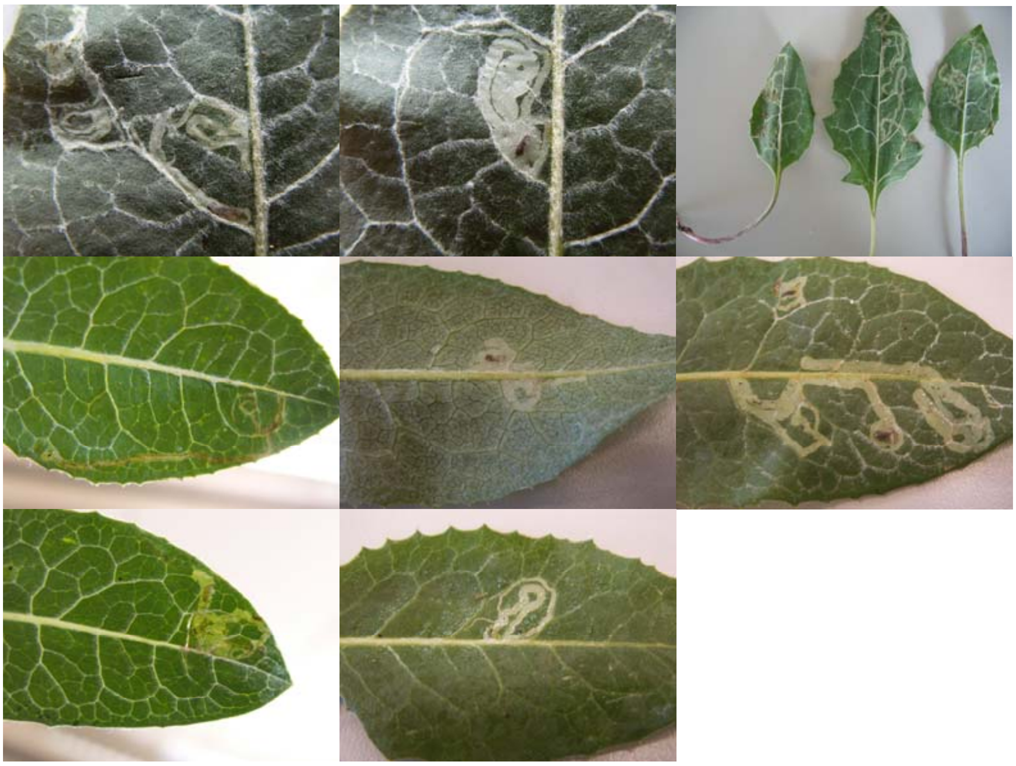
Miner not identified

Serratula flavescens (L.) Poir. subsp. *leucantha* (Cav.) Cantó & M.J. Costa

Phytomyza sp.

Serratula pinnatifida (Cav.) Poir

Chromatomyia horticola (Goureau, 1851)



Sonchus oleraceus L.

Chromatomyia horticola (Goureau, 1851)

Ophiomyia beckeri (Hendel, 1923)
No image

Liriomyza trifolii (Burgess in Comstock, 1880)

Sonchus tenerrimus L.

Chromatomyia horticola (Goureau, 1851)

Ophiomyia beckeri (Hendel, 1923)

Taraxacum obovatum (Willd.) DC.

Ophiomyia beckeri (Hendel, 1923)

Chromatomyia horticola (Goureau, 1851)

Taraxacum vulgare (Lam.) Schrank

Chromatomyia horticola (Goureau, 1851)

Urospermum delechampii (L.) Scop. Ex. F. W. Schmidt

Miner not identified

Urospermum picroides (L.) Scop. Ex F. W. Schmidt

Chromatomyia horticola (Goureau, 1851)

Ophiomyia beckeri (Hendel, 1923)
No image

Liriomyza trifolii(Burgess *in* Comstock, 1880)
No image

Xeranthemum inapertum (L.) Mill

Chromatomyia horticola (Goureau, 1851)

Convolvulaceae

Convolvulus althaeoides L.

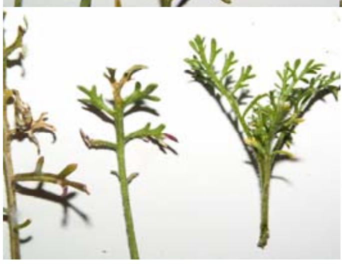
Chromatomyia horticola (Goureau, 1851)
No image

Cruciferae

Carrichtera annua (L.) DC

Liriomyza sp.



Diplotaxis erucoides (L.) DC

Chromatomyia horticola (Goureau, 1851)




Liriomyza brassicae (Riley, 1884)
No image

Liriomyza strigata (Meigen, 1830)
No image

Hirschfeldia incana (L.) Lagrèze-Fossat

Chromatomyia horticola (Goureau, 1851)

Liriomyza brassicae (Riley, 1884)

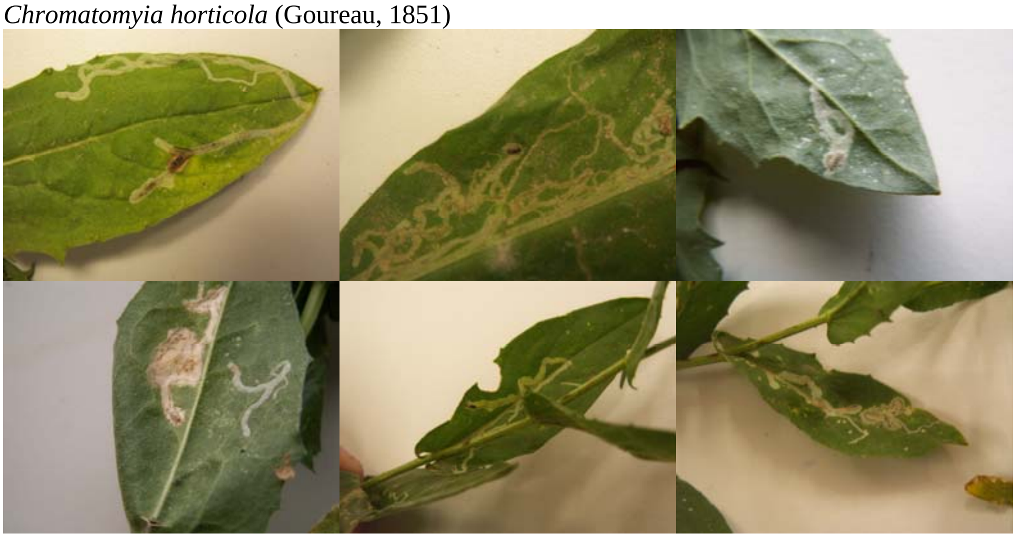
Iberis saxatilis L. subsp. *saxatilis*

Miner not identified

Lepidium draba L.

Amauromyza (Cephalomyza) flavifrons (Meigen, 1830)
No image

Chromatomyia horticola (Goureau, 1851)



Liriomyza brassicae (Riley, 1884)

Liriomyza strigata (Meigen, 1830)
No image

Ophiomyia beckeri (Hendel, 1923)
No image

Rapistrum rugosum (L.) All.

Miner not identified




Silene saxifraga L.

Miner not identified


Sinapis alba L.

Chromatomyia horticola (Goureau, 1851)

Sisymbrium crassifolium subsp. *laxiflorum* (Boiss.) O. Bolòs & Vigo

Chromatomyia horticola (Goureau, 1851)


Sisymbrium irio L.

Chromatomyia horticola (Goureau, 1851)


Liriomyza brassicae (Riley, 1884)
No image

Liriomyza bryoniae (Kaltenbach, 1858)
No image

Ophiomyia beckeri (Hendel, 1923)
No image

Sisymbrium officinale (L.) Scop.

Chromatomyia horticola (Goureau, 1851)

Liriomyza brassicae (Riley, 1884)

Sisymbrium orientale L.

Chromatomyia horticola (Goureau, 1851)

Liriomyza brassicae (Riley, 1884)

Liriomyza strigata (Meigen, 1830)
No image

Chenopodiaceae

Chenopodium vulvaria L.

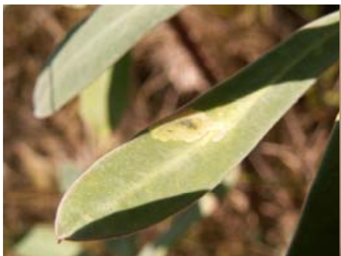
Miner not identified

Arthrocnemum macrostachyum (Moric.) Morris

Miner not identified

Euphorbia characias L.

Liriomyza pascuum (Meigen, 1838)




Euphorbia esula L.

Miner not identified

Euphorbia nicaeensis All.

Liriomyza pascuum (Meigen, 1838)

Euphorbia paralias L.

Miner not identified

Euphorbia serrata L.

Miner not identified

Dipsacaceae

Knutia arvensis (L.) Coulter

Chromatomyia horticola (Goureau, 1851)

Knautia purpurea (Vill.) Borbás

Chromatomyia horticola (Goureau, 1851)

Knautia rupicola (willk.) Font Quer

Liriomyza strigata (Meigen, 1830)
No image

Geraniaceae

Geranium rotundifolium L.

Miner not identified

Geranium molle L.

Miner not identified

Graminae

Arrhenatherum elatius (L.) P. Beauv. Ex J. & C. Presl

Miner not identified

Avena barbata Pott ex Link

Pseudonapomyza atratula Zlobin, 2002

Avena byzanthina C. Koch

Chromatomyia horticola (Goureau, 1851)
No image

Avena fatua L.

Miner not identified

Avena sativa L.

Miner not identified

Avena sterilis L.

Miner not identified

Brachypodium retusum (Pers.) P. Beauv.

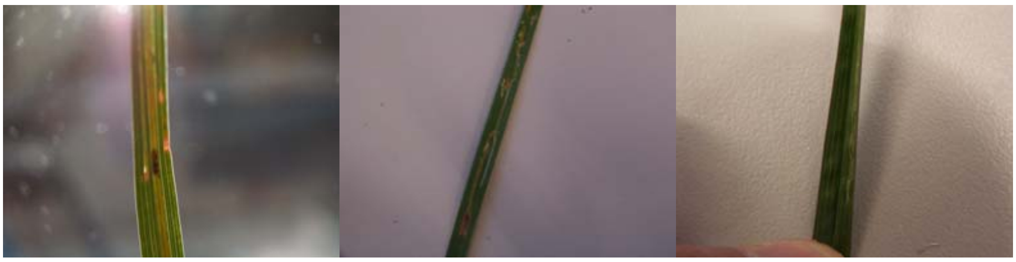
Miner not identified

Bromus fasciculatus Presl

Miner not identified

Dactylis glomerata L.

Miner not identified



Hordeum murimum L. subsp. *leporinum* (Link) Arcang.

Miner not identified




Setaria viridis (L.) P. Beauv.

Miner not identified

Labiatae

Ballota hirsuta Benth.

Miner not identified


Marrubium vulgare L.

Amauromyza (Amauromyza) morionella (Zetterstedt, 1848)
No image

Phlomis lychnitis L.

Miner not identified

Teucrium ronnigeri Sennen

Miner not identified

Leguminosae

Anagallis arvensis L. subsp. *arvensis*

Miner not identified

Anthyllis vulneraria subsp. *praepropera*

Miner not identified

Astragallus sesameus L.

Liriomyza congesta (Becker, 1903)

Colutea arborescens L.

Miner not identified
No image

Coronilla scorpioides (L.) Kotch

Miner not identified

Cytisus heterochrorus Webb ex Colmeiro

Miner not identified

Cytisus reverchonii (Degen & Hervier) Bean

Miner not identified

Hippocrepis comosa L.

Miner not identified

Lathyrus aphaca L.

Liriomyza congesta (Becker, 1903)

Lathyrus latifolius L.

Liriomyza congesta (Becker, 1903)

Lathyrus saxalitis (Vent.) Vis.

Miner not identified

Lotus corniculatus L. subsp. *corniculatus*

Liriomyza congesta (Becker, 1903)

Medicago lupulina L.

Liriomyza congesta (Becker, 1903)

Medicago minima L.

Liriomyza cicerina (Rondani, 1875)

Miner not identified

Medicago orbicularis (L.) Bartal

Miner not identified

Medicago polimorpha L. subsp. *polymorpha*

Miner not identified

Medicago rigidula (L.) *Mill.*

Miner not identified

Medicago sativa L.

Ophiomyia ononidis Spencer, 1966
No image

Chromatomyia horticola (Goureau, 1851)

Liriomyza cicerina (Rondani, 1875)
No image

Liriomyza congesta (Becker, 1903)

Medicago suffruticosa Ramond ex DC. In Lam. Et DC.

Miner not identified: feeding punctures of Agromyzidae

Melilotus officinalis (L.) Pallas

Miner not identified

Ononis fruticosa L. subsp. *macrophylla* (DC.) Bolòs & al.

Miner not identified

Ononis ornithopodioides L.

Miner not identified

Ononis spinosa L. subsp. *australis* (Sirj.) Greuter & Burdet

Liriomyza congesta (Becker, 1903)

Trifolium pratense L.

Miner not identified

Trifolium repens L.

Miner not identified

Trifolium scabrum L.

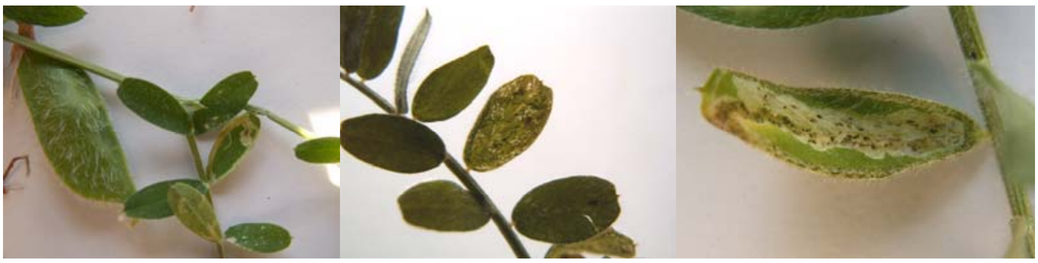
Miner not identified

Vicia hirsuta (L.) S. F. Gray

Liriomyza congesta (Becker, 1903)

Vicia hybrida L.

Liriomyza congesta (Becker, 1903)



Vicia sativa L. subsp. *sativa*

Chromatomyia horticola (Goureau, 1851)

Liriomyza congesta (Becker, 1903)

Vicia villosa Roth subsp. *varia*

Liriomyza congesta (Becker, 1903)

Malva parviflora L.

Chromatomyia horticola (Goureau, 1851)

Orchidaceae

Fam: Orchidaceae

Miner not identified

Papaveraceae

Papaver rhoeas L.

Chromatomyia horticola (Goureau, 1851)

Sisymbrium irio L.

Ophiomyia beckeri (Hendel, 1923)
No image

Chromatomyia horticola (Goureau, 1851)

Liriomyza bryoniae (Kaltenbach, 1858)
No image

Liriomyza brassicae (Riley, 1884)
No image

Plantaginaceae

Plantago albicans L.

Phytomyza plantaginis Robineau-Desvoidy, 1851

Plantago lagopus L.

Phytomyza plantaginis Robineau-Desvoidy, 1851

Chromatomyia horticola (Goureau, 1851)

Plantago lanceolata L.

Phytomyza plantaginis Robineau-Desvoidy, 1851

Chromatomyia horticola (Goureau, 1851)

Primulaceae

Anagallis arvensis L.

Chromatomyia horticola (Goureau, 1851)

Ranunculaceae

Clematis vitalba L.

Miner unknown

Helleborus foetidus L.

Phytomyza hellebori Kaltenbach, 1872

Ranunculus sardous Crantz.

Miner not identified

Thalyctrum tuberosum L.

Miner not identified

Resedaceae

Reseda phyteuma L.

Miner not identified


Reseda stricta Pers.

Chromatomyia horticola (Goureau, 1851)
No image

Rosaceae

Prunus dulcis (Miller.) D.A. Webb *var. Dulcis*

Miner not identified




Rubiaceae

Galium verrucosum Huds.

Miner not identified

Scrophulariaceae

Bellardia trixago (L.) All.

Liriomyza sp.

Solanaceae

Hyoscyamus albus L.

Miner not identified

Lycopersicon esculentum Miller

Liriomyza strigata (Meigen, 1830)

Umbelliferae

Bupleurum fruticescens L.

Miner not identified

Bupleurum rididum L.

Miner not identified

Urticaceae

Parietaria judaica L.

Miner not identified